DEPARTMENT OF MECHANICAL ENGINEERING

Course Book for

M. Tech. in

Heat Power Engineering

For

Academic Year: 2020 - 2021

Visvesvaraya National Institute of Technology,

Nagpur-440 010 (MH)

Institute Vision Statement

To contribute effectively to the National and International endeavour of producing quality human resource of world class standard by developing a sustainable technical education system to meet the changing technological needs of the Country and the World incorporating relevant social concerns and to build an environment to create and propagate innovative technologies for the economic development of the Nation.

Institute Mission Statement

The mission of VNIT is to achieve high standards of excellence in generating and propagating knowledge in engineering and allied disciplines. VNIT is committed to providing an education that combines rigorous academics with joy of discovery. The Institute encourages its community to engage in a dialogue with society to be able to effectively contribute for the betterment of humankind.

Department Vision Statement

To produce quality human resource of high standard in mechanical engineering who can contribute favorably to the technological and socio-economic development of the nation.

Department Mission Statement

To develop state of the art facilities related to mechanical engineering. To attract highly qualified faculty to the mechanical engineering department. To promote participation of industries in academics, research and consultancy. To undertake research at regional and national level.

Brief about Mechanical Department

Department of Mechanical Engineering is one of the oldest department started in 1960, scurrently department is offering 1 UG and 3 PG programmes. Faculty members of the department are highly motivated for teaching and conducting research in the diversified fields of mechanical engineering.

List of faculty Members

Sr No	Faculty Name	Areas of specialization
1	Dr. P. M. Padole	Design Engineering
2	Dr. H. T. Thorat	Design and Industrial Engineering
3	Dr. S. B. Thombre	Thermal Engineering
4	Dr. A. M. Kuthe	Manufacturing
5	Dr. V. R. Kalamkar	Thermal Engineering
6	Dr. A. Chatterjee	Design Engineering
7	Dr. Y. M. Puri	Manufacturing and Industrial Engineering
8	Dr. D. B. Zodpe	Thermal Engineering
9	Dr. A. B. Andhare	Manufacturing
10	Dr. J. G. Suryawanshi	Thermal Engineering
11	Dr. S. S. Chiddarwar	Manufacturing and Design Engineering
12	Dr. R. V. Uddanwadikar	Design Engineering
13	Dr. A. S. Dhoble	Thermal Engineering
14	Dr. H.P. Jawale	Design Engineering
15	Dr. M. S. Kotambkar	Design Engineering
16	Dr. A. K. Singh	Design and Thermal Engineering
17	Dr. Trushar B Gohil	Thermal Engineering
18	Dr. T. V. K. Gupta	Manufacturing
19	Dr. Ravikumar Dumpala	Manufacturing
20	Dr. R. K. Peetala	Thermal Engineering
21	Dr. P. V. Kane	Industrial Engineering
22	Dr. D. A. Jolhe	Industrial Engineering
23	Dr. V. M. Nistane	Design Engineering
24	Dr. G. Tiwari	Design Engineering
25	Dr. S Roga	Thermal Engineering
26	Dr. A. A. Thakre	Design and Industrial Engineering
27	Dr. K. M. Asthankar	Industrial Engineering
28	Dr. P. D. Sawarkar	Thermal Engineering
29	Dr. N. K. Lautre	Industrial Engineering

UG/ PG Programmes Offered by Mechanical Department:

The department offers following undergraduate and postgraduate programmes

	Program	Description
UG	B. Tech in Mechanical Engineering	Intake: 115
PG	M. Tech. in 1. Computer Aided Design & Manufacturing 2. Industrial Engineering 3. Heat Power Engineering	Intake : 25 each

Credit System at VNIT :

Education at the Institute is organized around the semester-based credit system of study. The prominent features of the credit system are a process of continuous evaluation of a student's performance / progress and flexibility to allow a student to progress at an optimum pace suited to his/her ability or convenience, subject to fulfilling minimum requirements for continuation. A student's performance/progress is measured by the number of credits he/she has earned, i.e. completed satisfactorily. Based on the course credits and grades obtained by the student, grade point average is calculated. A minimum number of credits and a minimum grade point average must be acquired by a student in order to qualify for the degree.

Course credits assignment

Each course, except a few special courses, has certain number of credits assigned to it depending on lecture, tutorial and laboratory contact hours in a week.
For Lectures and Tutorials: One lecture hour per week per semester is assigned one credit and
For Practical/ Laboratory/ Studio: One hour per week per semester is assigned half credit.
Example: Course XXXXXX with (3-0-2) as (L-T-P) structure, i.e. 3 hr Lectures + 0 hr Tutorial + 2 hr Practical per week, will have (3x1 + 0x1 + 2x0.5 =) 4 credits.

Grading System

The grading reflects a student's own proficiency in the course. While relative standing of the student is clearly indicated by his/her grades, the process of awarding grades is based on fitting performance of the class to some statistical distribution. The course coordinator and associated faculty members for a course formulate appropriate procedure to award grades. These grades are reflective of the student's performance vis-à-vis instructor's expectation. If a student is declared pass in a subject, then he/she gets the credits associated with that subject.

Depending on marks scored in a subject, a student is given a Grade. Each grade has got certain grade points as follows:

Grade	Grade points	Description
AA	10	Outstanding
AB	9	Excellent
BB	8	Very good
BC	7	Good
CC	6	Average
CD	5	Below average
DD	4	Marginal (Pass Grade)
FF	0	Poor (Fail) /Unsatisfactory / Absence from end-sem exam
NP	-	Audit pass
NF	-	Audit fail
SS	-	Satisfactory performance in zero credit core course
ZZ	-	Unsatisfactory performance in zero credit core course
W	-	Insufficient attendance

Performance Evaluation

The performance of a student is evaluated in terms of two indices, viz, the Semester Grade Point Average (SGPA) which is the Grade Point Average for a semester and Cumulative Grade Point Average (CGPA) which is the Grade Point Average for all the completed semesters at any point in time. CGPA is rounded up to second decimal.

The Earned Credits (ECR) are defined as the sum of course credits for courses in which students have been awarded grades between AA to DD. Grades obtained in the audit courses are not counted for computation of grade point average.

Earned Grade Points in a semester (EGP) = **Σ** (Course credits x Grade point) for courses in which AA- DD grade has been obtained

SGPA = EGP / Σ (Course credits) for courses registered in a semester in which AA- FF grades are awarded

CGPA= EGP / Σ(Course credits) for courses passed in all completed semesters in which AA- DD grades are awarded

Overall Credits Requirement for Award of Degree

SN	Category of Course	Symbol	Credit Requirement			
			B. Tech. (4-Year)	B. Arch. (5 Year)	M. Tech. (2 Year)	M. Sc. (2 Year)
Program Core						
1	Basic Sciences (BS)	BS	18	04	-	-
2	Engineering Arts & Sciences (ES)	ES	20	18	-	-
3	Humanities	HU/ HM*	05	06	-	-
4	Departmental core	DC	79-82	168	33-39	54-57
Program Elective						
3	Departmental Elective	DE	33-48	17-23	13-19	06-09
4	Humanities & Management	HM	0-6	0-3	-	-
5	Open Course	OC	0-6	0-3	-	-
Total requirement :BS + ES + DC+ DE + HM + OC =			**170**	**219**	**52**	**63**
Minimum Cumulative Grade Point Average required for the award of degree			**4.00**	**4.00**	**6.00**	**4.00**

Attendance Rules

1. All students must attend every class and 100% attendance is expected from the students. However, in consideration of the constraints/ unavoidable circumstances, the attendance can be relaxed by course coordinator only to the extent of not more than 25%. Every student must attend minimum of 75% of the classes actually held for that course.
2. A student with less than 75% attendance in a course during the semester, will be awarded W grade. Such a student will not be eligible to appear for the end semester and re-examination of that course. Even if such a student happens to appear for these examinations, then, answer books of such students will not be evaluated.
3. A student with W grade is not eligible to appear for end semester examination, reexamination & summer term.

Program Outcomes for M. Tech (Common to all PG programmes):

a. An ability to independently carry out research /investigation and development work to solve practical problems.
b. An ability to write and present a substantial technical report/document.
c. Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.

List of courses for the PG Programme

M.Tech in Heat Power Engineering

I. To be offered in Odd semester

S. No	Code	Title	DC/DE	Structure L-T-P	Credit	Pre-requites
1	MEL 511	Fluid Dynamics	DC	3-0-0	3	
2	MEL 512	Engineering Thermodynamics and Combustion	DC	3-0-0	3	
3	MEL 513	Advanced Heat Transfer	DC	3-0-0	3	
4	MEP 524	Heat and Mass Transfer Lab	DC	0-0-2	1	
5	MEL 435	Computational Fluid Dynamics	DC	3-0-0	3	
6	MEP 435	Computational Fluid Dynamics Lab	DC	0-0-2	1	
7	MED 501	Project Phase I	DC		3	25 Credits
8	MEL527	Hydraulics and Pneumatics	DE	3-0-0	3	
9	MEP527	Hydraulics and Pneumatics	DE	0-0-2	1	
10	MEL528	Gas Dynamics	DE	3-0-0	3	
11	MEP528	Gas Dynamics Lab	DE	0-0-2	1	
12	MEL 417	Power Plant Engg	DE	3-0-0	3	
15	MEL508	Energy Management	DE	3-0-0	3	

Chairman BoS
Name & Signature
(To sign on every page of the document)

II. To be offered in Even semester

S. No	Code	Title	DC/DE	Structure L-T-P	Credit	Pre requites/Remark
1	MEL430	Advanced IC Engines	DC	3-0-0	3	
2	MEP430	Advanced IC Engines Lab	DC	0-0-2	1	
3	MEL444	Solar Energy Utilization	DC	3-0-0	3	
4	MEL 438	Adv Refrigeration and Air Conditioning	DC	3-0-0	3	
5	MEP 438	Adv Refrigeration and Air Conditioning Lab	DC	0-0-2	1	
6	MED 502	Project Phase-II	DC		9	35 Credits+ Project Phase I
7	MEL 449	Advanced Turbo Machinery	DE	3-0-0	3	
8	MEL 507	Adv CFD	DE	3-0-0	3	MEL 435
9	MEL 443	Air Pollution Control	DE	3-0-0	3	
10	MEL 525	Multiphase Flow	DE	3-0-0	3	
11	MEL 516	Fuel Cell Technology	DE	3-0-0	3	MEL513
12	MEP 516	Fuel Cell Technology	DE	0-0-2	1	
13	MEL ***	Bio Energy Conversion	DE	3-0-0	3	
14	MEL ***	Design & Optimization of Thermal Energy Systems	DE	3-0-0	3	

III. Total credits to be earned for completion of the degree program:

a) Through DC category courses = 37 credits
b) Through DE category courses = 15 credits

Total = 52 Credits

IV. This DC/DE categorization of the courses for the M.Tech Program in Heat Power Engineering is applicable for the students admitted to the first semester of the programme during the academic year 2020-2021.

Odd Semester

MEL511FLUID DYNAMICS

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

Upon successful completion of this course students should be able to:

1. Understand various types of fluid flow and able derive basic fundamental equations applied to fluid flow.
2. Apply correctly the conservation principles of mass, linear momentum, and energy to fluid flow systems.
3. Understand the concepts required for interpretation of analysis results of fluid flow problems generated using mathematical analysis

Content:

Boundary Layer Theory

Concept of boundary layer, flow over a flat plate, Navier-Stokes's equations and it's use. Von-Karmann Momentum Equation. General properties of boundary layer. Exact solution of two-dimensional methods. Correlation coefficient.

Compressible Flows

Concept of compressible flow, one dimensional isentropic flow, normal shock, flow with frictional heat transfer, Reyleigh and fanno lines.

Text Books/ Reference Books:

1. Kumar D.S., "Fluid Mechanics and Fluid Machines", S.K.Kataria & Sons, 4th Ed, 1992
2. Bansal R.K, "Fluid Mechanics and Fluid Machines", Laxmi Publications, 2002.
3. Massey B.S., "Mechanics of Fluids", Van Nostrand Reinhold Co., 1989.
4. Yahya S.M., "Fundamentals of Compressible Flow," New Age Int., 3rd Ed., 2004

MEL512ENGINEERING THERMODYNAMICS AND COMBUSTION

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

1. Learn the concept of energy availability and analysis of thermodynamic systems.
2. Apply basic laws of thermodynamics in analysis and design of thermodynamic cycles including vapor and gas power cycles, refrigeration cycles, and heat-pump.
3. Develop understanding how thermodynamic relations are used in evaluation of thermodynamic properties.
4. Learn how to apply the fundamentals of conservation of mass and energy, and properties of ideal gas mixtures in design and analysis of psychrometric systems.
5. Learn the thermodynamic analysis of reacting mixtures and the applications in analysis of combustion processes

Content:

First law of thermodynamics

Equation of state, properties of gas mixtures, first law of thermodynamics, enthalpy of formation and heat of reaction, adiabatic flame temperature

Second law of thermodynamics

Second law of thermodynamics and concept of chemical equilibrium, Gibbs free energy and the equilibrium constant of chemical reaction.

Combustion

Combustion, determination of flame velocity and length. Empirical correlations. Models of ignition and quenching. Flammability limits and their use. Burning of solid particles, diffusion and kinetically controlled combustion. Combustion in fluidized beds.

Pollution;Estimation of pollutants emission (CO, NOx, HC), emission indices & control measures.

Text Books/ Reference Books:

1. Van Wylen, G.J, “Fundamentals of classical thermodynamics”, Wiley Eastern, 1978.
2. HolmanJ.P, “Thermodynamics”, Mc-Graw Hill International,Kogakusha, 3rd Ed, 1980.
3. Cengel, Y.A.,Boles M.A , “Thermodynamics”, McGraw Hill, 3rd Ed,

MEL513ADVANCED HEAT TRANSFER

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

1. Course Outcomes/ Objectives:
2. On successful completion of this course, the students will be able to
3. Analyse multidimensional transient & steady state heat transfer through solids
4. Predict heat transfer coefficient on different surfaces/ tube banks and design of heat exchanging equipments.
5. Estimate radiative heat transfer in enclosures with/ without participating media
6. Analyse one dimensional steady state mass transfer rate for different situations

Content:

Conduction: Multidimensional heat flow; steady state and unsteady state, with and without heat generation. Longitudinal and circumferential fins/ spines with rectangular and nonrectangular profiles. Analytical methods and numerical techniques.

Convection

Basic concepts, hydrodynamic and thermal boundary layers, momentum and energy integral equations, Natural, forced and two phase convection heat transfer characteristics for different geometries, Empirical correlations. Nusselt theory for film wise condensation on vertical plates, condensation on horizontal tube banks. Design of single/ multiple pass heat exchangers.

Radiation

Basic concepts and laws governing radiation, coloured body, radiosity and irradiation, Shape factors for non standard geometries, Radiation in enclosures, multilayer insulation, radiation with participating media, gaseous emissions and absorption.

Mass Transfer

Fick's law of diffusion, Diffusion coefficient, steady state diffusion of gases and liquids through solids, isothermal evaporation, mass transfer coefficient, analogy between heat and mass transfer

Text Books/ Reference Books:

1. Incropera F P, Dewitt D P, "Introduction to heat transfer",4th Ed, 1996, John Wiley & Sons
2. Holman J.P., "Heat transfer", 9th Ed 2004, McGraw Hill
3. Nag P K, "Heat and Mass Transfer", 3rd Ed, 2011, McGraw Hill

MEP524 HEAT AND MASS TRANSFER

1 credit (0-0-2)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

To impart practical knowledge to the students on how to;

1. Determine temperature dependence of thermal conductivity of materials
2. Establish heat transfer characteristics for different geometries, fluid flows & during phase change
3. Estimate various radiative properties such as emissivity, Stephan Boltzmann constant, etc
4. Analyze heat exchanging gadgets like boilers, heat exchangers, solar heaters, etc.
5. Estimate diffusion coefficient and mass transfer coefficient

Content:

Following is the list of experiments (minimum 8 but covering all the COs)

1. CO1: To study the temperature dependence of thermal conductivity of a material.
2. CO1: Determination of efficiency of a pin fin with different profiles.
3. CO2: Comparison of exact and lumped capacitance method of transient conduction.
4. CO2: Determination of two phase heat transfer coefficient inside a pipe
5. CO2:Determination of buoyancy induced flow inside a pipe
6. CO2:Determination of forced convection heat transfer characteristics for flow through pipes
7. CO2:Determination of natural convection heat transfer characteristics for inclined plates.
8. CO3:Determination of effective emissivity of a surface in presence of participating medium
9. CO3:To study the effect of shield(s) on radiation heat transfer
10. CO4:Determination of overall heat transfer coefficient for shell & tube type heat exchangers
11. CO4:Parametric studies on the performance of a solar collector
12. CO5:Determination of diffusion coefficient of liquid in air
13. CO5:Determination of mass transfer coefficient

Text Books/ Reference Books:

MEL435COMPUTATIONAL FLUID DYNAMICS

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

At the end of this course, the student will be able to:

1. Understand and be able to numerically solve the governing equations for fluid flow
2. Understand and apply finite difference, finite volume and finite element methods to fluid flow problems
3. Understand how grids are generated
4. Understand how to assess stability and conduct a grid-convergence assessment
5. Understand and apply turbulence models to engineering fluid flow problems
6. Understand and apply compressible flow solvers
7. Understand the issues surrounding two-phase flow modelling
8. Be able to numerically solve a heat transfer problem
9. Be able to use ANSYS CFX to an acceptable standard for a graduate engineer.

Content:

Equations of fluid dynamics

Basic concepts Eulerarian and Lagrangian methods of describing fluid flow motion, acceleration and deformation of fluid particle, vorticity. Laws governing fluid motion, continuity, Navier – stokes & energy equations. Boundary layer equation, Euler equations, potential flow equations, Bernoulli's equation and vorticity transport equation. Initial and boundary conditions. Classification of equation of motions – hyperbolic, parabolic, elliptic.

Mathematical Preliminaries

Numerical integration. Review of linear algebra, solution of simultaneous linear algebraic equations – matrix inversion, solvers – direct methods, elimination methods, ill conditioned systems; Gauss- Sidel method, successive over relaxation method.

Grid Generation

Transformation of coordinates. General principles of grid generation – structured girids in two and three dimensions, algebraic grid generation, differential equations based grid generation;

Elliptic grid generation, algorithm, Grid clustering, Grid refinement, Adaptive grids, Moving grids. Algorithms, CAD interfaces to grid generation. Techniques for complex and large problems: Multi block methods.

Finite difference discretization

Elementary finite difference coefficients, basic aspects of finite difference equations, consistency, explicit and implicit methods, errors and stability analysis. Stability of elliptic and hyperbolic equations. Fundamentals of fluid flow modeling-conservative property, upwind scheme, transporting property, higher order upwinding. Finite difference applications in heat transfer – conduction, convection.

Finite Volume Method

Introduction, Application of FVM in diffusion and convection problems, NS equations – staggered grid, collocated grid, SIMPLE algorithm. Solution of discretised equations using TDMA.Finite volume methods for unsteady problems – explicit schemes, implicit schemes. Finite Element Method: Introduction. Weighted residual and variational formulations. Interpolation in one-dimensional and two-dimensional cases. Application of FEM to ID and 2D problems in fluid flow and heat transfer

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Text Books/ Reference Books:

1. Ferziger J. H., Springer P.M, "Computational Methods for fluid Dynamics", Verlag Berlin
2. Anderson J. D. JR, "Computational fluid Dynamics", Mc Graw Hill Inc, 1995
3. Patankar S. P, " Numerical Heat Transfer & Fluid flow"
4. Sunderarajan M.K., "Computational Fluid Flow and Heat Transfer", 2nd Ed, Narosa Publishing

MEP435COMPUTATIONAL FLUID DYNAMICS

1 credit (0-0-2)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

1. To provide students with the necessary skills to use commercial CFD packages
2. To carry out research in the area of Computational Fluid Dynamics.

3. To solve a variety of flow situations and heat transfer tutorials.

Content:

The set of tutorials designed to provide the student with the necessary tools for using sophisticated commercial Ansys fluent CFD software. A set of laboratory tasks will take the student through a series of increasingly complex flow and heat transfer simulations, requiring an understanding of the basic theory of computational fluid dynamics (CFD).
At the end of the course each student will have to complete a mini project.

Text Books/ Reference Books:

MEL527 HYDRAULICS AND PNEUMATICS
3 credits (3-0-0)
Pre-requisites: Nil
Overlaps with:

Course Outcomes/ Objectives:

1. The students will able to understand various definitions, theoretical concepts and derive equations related to fluid properties and relationship between them, and apply the equations to various hydraulic and pneumatic components. (CO1)
2. The students will able to understand principles of working of various measuring devices used in hydraulic and pneumatic circuits like pumps, valves, hydraulic motors etc., from undergraduate perspective. (CO2)
3. The students will able to apply mathematical treatment to various problems related to fluid systems and calculate the values of various parameters and design simple hydraulic and pneumatic circuits. (CO3)

Content:

1. Basic Concepts of Hydraulics : Introduction & definitions of important terms like hydraulics, pressure, force, vacuum etc., Pascal’s law and its application to hydraulics, Bernoulli's principle , Hydraulic jack, Hydraulic symbols, Advantages and disadvantages of hydraulic system, Hydraulic oil, purpose, ideal characteristics of hydraulic oil, maintenance of hydraulic oil, Relief valve & safety valve. (CO1)
2. Accessories of Hydraulic System: Connectors - steel pipe, tubing, hose, Gauges, Packing &

seals, Filters & strainers, Hydraulic tank, Plumbing, pipes & tubes, installation. (CO1)

3. Hydraulic Valves And Auxiliaries : Directional control valves, Pressure control valves, Flow control valves, Relief valve & safety valve, Pressure intensifiers, Actuators – rotary, oscillatory & linear, force speed / torque speed diagram, selection of actuator, speed control, Accumulators, Cartridge valves, Proportional valves – types, Introduction to servo-hydraulic systems.(CO2)

4.Hydraulic Pumps and Motors: The power pack, elements of power pack, Positive displacement pump, fixed delivery/variable delivery, Pump characteristics and specifications, Construction & working of gear pump, vane pump, radial piston pump, Pump maintenance & trouble shooting, Hydraulic motor specifications, Construction & working of gear motor, vane motor, radial piston motor, Storage, commissioning, trouble shooting, maintenance and safety (CO2)

5. Hydraulic Circuits: Clamp control circuit, Injection control circuit, Reciprocating screw circuit, Oil filtration circuit, Deceleration circuit, Prefill circuit, Hydraulic motor circuit, Hi-low pump circuit, Meter–in, meter–out & bypass circuits, Designing, simulation and testing of hydraulic control circuits for simple as well as complex machine systems (CO3)

6. Pneumatics: Pneumatics, symbols, Comparison with hydraulic system, Air Compressors, Compressed air, generation, control & distribution, Components of pneumatic system, Actuators, single and double acting cylinders, Air receiver, size determination and pressure control, Pressure loss calculation and air line design, Stages of air treatment – intercooler, lubricator, filter, air dryer, Design, operation and testing of pneumatic circuits for typical processing machines and heavy equipment (CO3)

7. Introduction to fluidics and safety aspects of hydraulic and pneumatic systems (CO1)

Text Books/ Reference Books:

1. Oil Hydraulic Systems: Principle and Maintenance by S. Majumdar, Publisher McGrawHill Publication,
2. Pneumatic System: Principles and Maintenance by S. Majumdar, Publisher McGrawHill Publication
3. Hydraulic and Pneumatic by Andrew Parr, Publisher: Elsevier Science & Technology Books
4. Fluid Mechanics and its applications by V. Gupta and S.K. Gupta, New Age International Publisher,2007

MEP527 HYDRAULICS AND PNEUMATICS

1 credit (0-0-2)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

Content:

1. Operation of double acting cylinder using4/3 hand lever valve (CO3)
2. Operation of double acting cylinder using4/2 hand lever valve (CO3)
3. Experimentation on actuator speed control circuit setup (CO1)
4. Experimentation on hydraulic accumulator (CO1)
5. Study of transverse and feedback circuit (CO2)
6. Experimentation on the operation of telescopic cylinder(CO2)
7. Study of pressure sequence valve in hydraulic circuit (CO2)
8. Demonstration of operation of limited rotary actuator (CO2)
9. Experimentation for verification of operation of regenerative circuit (CO2)
10. Design and operation of hydraulic brake circuit (CO3)

Text Books/ Reference Books:

MEL528GAS DYNAMICS

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

1. The student will be able to understand various definitions and theoretical concepts related to Fundamental Aspects of Gas Dynamics,Normal Shock Waves, Variable Area Flow, Flow with Heat addition and Two-Dimensional Compressible Flow to meet PG level requirement.
2. The student will be able to understand working of various systems related to gas dynamics: Shock waves, Adaiabatic Flow in a Duct, vorticity,velocity potential etc. from undergraduate perspective.
3. To teach student how to understand and apply mathematical treatment to various

problems related to Generalized Quasi-One-Dimensional Flow,Two-Dimensional Compressible Flow, shock wave relations, isentropic relations to reasonable correctness.

Content:

Fundamental Aspects of Gas Dynamics: Introduction, Isentropic flow in a stream tube, speed of sound, Mach waves; One dimensional Isentropic Flow: Governing equations, stagnation conditions, critical conditions, maximum discharge velocity, isentropic relations;

Normal Shock Waves: Shock waves, stationary normal shock waves, normal shock wave relations in terms of Mach number; Oblique Shock Waves: Oblique shock wave relations, reflection of oblique shock waves, interaction of oblique shock waves, conical shock waves; Expansion Waves: Prandtl-Meyer flow, reflection and interaction of expansion waves, flow over bodies involving shock and expansion waves ;

Variable Area Flow: Equations for variable area flow, operating characteristics of nozzles, convergent-divergent supersonic diffusers,Adaiabatic Flow in a Duct with Friction: Flow in a constant area duct, friction factor variations, the Fanno line ;

Flow with Heat addition or removal: One-dimensional flow in a constant area duct neglecting viscosity, variable area flow with heat addition, one-dimensional constant area flow with both heat exchanger and friction,Generalized Quasi-One-Dimensional Flow: Governing equations and influence coefficients, solution procedure for generalized flow with and without sonic point.

Two-Dimensional Compressible Flow: Governing equations, vorticity considerations, the velocity potential, linearized solutions, linearized subsonic flow, linearized supersonic flow, method of characteristics.

Text Books/ Reference Books:

1. H. W. Liepmann, and A. Roshko, Elements of Gas Dynamics, Dover Pub, 2001
2. L.D.Landau and E..M.Lifshitz, Fluid Mechanics. 2nd ed.,Butterworth-Heinemann, 1995
3. P. H. Oosthuizen and W. E. Carscallen. Compressible Fluid Flow. NY, McGraw-Hill, 1997
4. M.A.Saad,Compressible Fluid Flow. 2nd ed. Upper Saddle River, NJ: Prentice-Hall, 1993

MEP528 GAS DYNAMICS

1 credit (0-0-2)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

1. The student will be able to understand various definitions and theoretical concepts related to Fundamental Aspects of Gas Dynamics,Normal Shock Waves, Variable Area Flow, Flow with Heat addition and Two-Dimensional Compressible Flow to meet PG level requirement.
2. The student will be able to understand working of various systems related to gas dynamics: Shock waves, Adaiabatic Flow in a Duct, vorticity,velocity potential etc. from undergraduate perspective.
3. To teach student how to understand and apply mathematical treatment to various problems related to Generalized Quasi-One-Dimensional Flow, Two-Dimensional Compressible Flow, shock wave relations, isentropic relations to reasonable correctness.

Content:

1. The hypersonic boundary layer facility
2. The supersonic combustion facility
3. The 8 x 8 supersonic wind tunnel
4. The LTVG (Low Turbulence Variable Geometry) supersonic tunnel
5. The SuperPipe: High Reynolds number pipe flow facility
6. The SuperTunnel: High Reynolds number Test Facility (HRTF)
7. The water channel
8. The Taylor-Couette flow apparatus
9. The air system

Text Books/ Reference Books:

MEL417POWER PLANT ENGINEERING

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

On Successful completion of this course, The student will:

1. Know the various types of power plants used in Jordan.
2. Have Knowledge of the various types of conventional and non-conventional power plants.
3. Have Knowledge of the operation, construction and design of various components of power plants.
4. Able to calculate the performance parameters of various power plants.

Content:

Steam Power Plant: Reheat-regenerative cycle, binary cycle, topping and superimposed cycle.

Steam generators: Modern generators, once through and fluidized bed boilers design. Consideration of modern steam generators, furnace, fuel firing methods, fuel and ash handling systems, various accessories of steam generators, steam temperature control.

Steam Turbines: Details of construction, accessories, governing, turbine blades, power calculations, arrangement of turbines, industrial turbines.

Condensers and Cooling Towers: Performance, heat transfer design, calculations, efficiencies, detail construction, cooling water circuit, environmental aspects.

Hydro Electric Plant: Hydrology, rainfall measurement hydrographs, flow duration curves, site selection, classification of hydro stations, capacity of hydro stations, selection of prime movers, governing of water turbines, operation of different components of hydro station reservoirs, dam, spillway, canals, penstock, water hammer surge tank, Draft-tubes, specific speeds of turbines, Advantages of hydro station.

Gas Turbine Power Plant: General features and characteristics and their application power plants, Analysis of different cycles, components of gas turbine power plants, governing system of gas turbine plant, advantages of G. T. plant, Gas and steam turbines, combined cycles – Thermodynamic analysis for optimum design, advantages and performance of combined cycles, economics of combined cycle. Combined cycle with nuclear power plants, Diesel electric power plant: Thermodynamic cycle analysis, supercharge of diesel engines, different systems of diesel power plant, environmental aspects.

Power Plant Economics: Fluctuating load on power plants, load curves, various performance factors of power station. Effect of variable load power plant design and operation. Economic analysis of power plants, tariffs, load division, combined operation of different power plants, heat rate, incremental heat rate, selection of power plant and station equipments.

.

Text Books/ Reference Books:

1. Stroteki, Vopat, "Power Station Engineering & Economy", Tata Mc Graw Hill, 1977
2. Domkundawar, "Power Plant Engineering", Dhanpat Rai & Sons,1980
3. Nagpal G. R , "Plant Engineering", Khunna Publications, 1978

MEL508 ENERGY MANAGEMENT

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

1. Understanding of energy conservation and identification of energy conservation opportunities in various industrial processes
2. Knowledge of various tools and components and energy auditing
3. Ability to evaluate the performance of industrial boilers, furnaces etc. by direct and indirect methods
4. Understanding of cogeneration in industry and waste heat recovery techniques and devices

Mapping with POs:

POs → / COs ↓	a	b	c
CO1	H	M	H
CO2	M	M	H
CO3	M	H	M
CO4	-	M	H
Overall	M	M	H

Content:

Introduction: Importance of energy management, Energy auditing, methodology, analysis of past trends (plant data), closing the energy balance, laws of thermodynamics, measurements, portable and online instruments. Energy Economics: discount rate, payback period, internal rate of return, life cycle costing. CO1, CO2

Thermal & Mechanical systems: Boiler efficiency testing, excess air control, steam distribution and use of steam traps, condensate recovery, flash steam utilization, thermal insulation. Energy conservation in pumps, fan (flow control), Compressed air systems, Refrigeration and air conditioning systems. CO1, CO2, CO3

Electrical Systems: demand control, power factor correction, load scheduling / shifting, motor drives-motor efficiency testing, energy efficient motors, and motor speed control. CO1

Lighting: Lighting levels, efficient options, fixtures day lighting, timers, and energy efficient windows. CO1, CO2

Waste heat recovery: Recuperators, heat wheels, heat pipes, heat pumps. Cogeneration concept, options (steam / gas turbines / diesel engine based). Demand side management. CO1, CO2, CO4

Energy Auditing: Introduction, importance of energy audit, uses of energy audit basic terms of energy audit, types of energy audit, procedure for carrying energy audit, instruments used for energy audit. CO2

Text Books/ Reference Books:

1. Turker W. C., “Energy Management Handbook”, The Fairmont Press Lilburn, 1993
2. Witte, Schmidt, Brown , “Industrial Energy Management & Utilization”, Hemisphere Publications
3. Dryden, “The efficient use of Energy”, Butter worth, London, 1982

MED501 PROJECT PHASE - I

3 credits

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

Content:

Text Books/ Reference Books:

Even Semester

MEL430- Advanced IC Engines

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

On completion of the course students shall be able to:

1. Analyze engine cycles and the factors responsible for making the cycle different from the Ideal cycle
2. Apply principles of thermodynamics, fluid mechanics, and heat transfer to influence the engine's performance
3. To Demonstrate the delay period and fuel injection system
4. Demonstrate an understanding of the SI and CI engine performance

Content:

Introduction: Engines types and their operation, Introduction and Historical Perspective, Engine classifications, Engine operating cycles, Engine components, Engine friction, lubrication and cooling, lubrication systems. Frictional losses, blow by losses, pumping loss, Factors affecting mechanical friction

Fuels: Fluid, Solid, gaseous, liquid fuels, SI Engine fuels characteristics, C.I. Engine fuels, characteristics, Rating of engine fuels, I.C. engine fuels - petrol, diesel ENG, LPG, Alcohol, Vegetable oils, Combustion, Combustion stoichiometry - The firstlowof thermodynamics and combustion, Enthalpies of formation, Heating values combustion efficiency. The second law of thermodynamics applied to combustions. Maximum work, chemical equilibrium, theoretical flame temperature.

SI Engine: S. I. Engine fuel requirements, carburetors, factors attesting carburetion, moderns carburetors, metering systems, choke, altitude compensation, fuel injection systems, multipoint port injection, feedback systems, charge motion within the cylinder swirl, squish, combustion stages, flame propagation cyclic variations in combustion, ignition fundamentals, conventional ignition system, abnormal combustion, knock and surface ignition, knock fundamentals, turbo charging, supercharging and scavenging in engines.

C. I. Engines: Essential features of the process, combustion systems. Combustion in direct and indirect injection, fuel spray behavior. Fuel injection systems, fuel pumps, fuel injectors, atomization, combustion in C. I. Engines, ignition delay, certain number, auto ignition. Factors affecting delay. Effects of fuel properties. Abnormal combustion, supercharging and turbo charging in engines.

Pollutant formation & Control

Nature and extent of problem, Nitrogen oxides Kinetics of NO formation, formation of NO2 NO formation in S. I. Engines NOx formation in C. I. Engine Carbon monoxide and unearned hydrocarbon emissions in S.I. and C.I. engines, EGR Particulate emissions, measurement technique. Catalytic converters, particulate traps.

Engine Design and Operating Parameters : Important engine characteristics, Geometrical properties of Reciprocating engines, Brake, Torque & Power, Indicated work per cycle, Mechanical efficiency, Road load power, Mean effective pressure, Specific fuel consumption and efficiency, Air/Fuel and Fuel/Air ratios, Volumetric efficiency, Engine specific weight and specific volume, Correction factors for power and efficiency, Specific emission and emission index, Relationship between performance parameters

Measurement and Testing: Measurement of friction 'power indicated power, Brake power, Fuel consumption, Air consumption, Performance parameters and characteristics: Engine Power, Engine efficiencies, Engine performance characteristics, Variables affecting performance characteristics

Text Books/ Reference Books:

1. Heywood J.B, “Internal Combustion Engine Fundamentals”, McGraw Hill, 1988.
2. Obert E.F, “Internal Combustion Engines and Air pollution”, Intext Educational Pub, 1974
3. Ganesan V, “Internal Combustion Engines”, Tata Mc Graw Hill Publishing Co. , 6th Ed
4. Mathur M.C., Sharma.R.D , "Internal Combustion Engines", Dhanpat Rai Pub, 8th Ed 2003

MEP430ADVANCED IC ENGINES

1 credit (0-0-2)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

Upon successful completion students will be able to:

(i) Understand the current available engines, their operating principles and their characteristics

(ii) Be able to test the performance of engines

Content:

1. Study of Carburetors
2. Study of Fuel Injection Systems
3. Study of Engine Components
4. Performance Characteristics of C.I. Engine
5. Performance Characteristics of C.I. Engine
6. Experiment on Air Pollution

Text Books/ Reference Books:

MEL444 SOLAR ENERGY UTILIZATION

3 credits (3-0-0)

Pre-requisites: Heat transfer and Fluid mechanics

Overlaps with: Renewal Energy Sources

Course Outcomes/ Objectives :

After completion of this course, student will be able to

1. learnthe fundamentals of geometry of solar radiation
2. performance analysis of solar thermal systems
3. analyze the basics of renewal sources of energy

Content:

Geometry of solar radiation and applications [1]

Solar Thermal systems such as liquid flat plate collector, air heater and concentrating collector, Solar pond, Solar distillation, Solar drying. Thermal storage. Modelling of above systems, Steady state and transient analysis, simulation in process design. [1,2]

Design and performance analysis of PV systems [1,2]

Different sources of renewal energy: Need for alternative sources of energy, various options available, principles of energy conversion using solar energy, wind energy, Ocean energy, Geothermal energy and MHD power generation [1,3]

Text Books/ Reference Books:

1. Sukhatme S.P , “Solar energy,” Tata McGraw Hill, 2nd Ed 2003
2. Duffie, Beckman, “Solar energy”, John Wiley & Sons, 1974
3. Parulekar B.B., Rao S, “Energy technology”, Khanna Publishers, 3rd Ed 1995

MEL438 ADVANCED REFRIGERATION AND AIR CONDITIONING

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with: Nil

Course Outcomes/ Objectives:

Upon successful completion students will be able to:

1. understand various definitions and theoretical concepts related to single stage/ multistage refrigeration, air cycle refrigeration, cryogenics and for alternate refrigeration systems like vapour absorption, steam jet, vortex tube and thermoelectric refrigeration and cryogenics to meet PG level requirement.
2. understand various concepts related to air conditioning like psychrometrics / psychrometric processes, comfort and its measurement, effective temperature, comfort chart and its use, method of cooling load calculation, design process for summer/monsoon/winter Air conditioning and duct design to meet PG level requirement.
3. Understand working of various equipments/systems used in refrigeration and air conditioning like compressors, condensers, evaporators, expansion devices, controls, Air washers, AHU's cooling towers, refrigerator, air conditioner etc. from post graduate perspective.
4. Understand and apply mathematical treatment to various problems related to single/multistage, vapour absorption, air cycle and refrigeration, psychrometrics, psychrometric processes, design of summer/ winter/monsoon air conditioning and duct design to reasonable correctness.

Mapping with POs:

POs → / COs ↓	a	b	c
CO1	H	M	H
CO2	H	M	H
CO3	M	M	M
CO4	H	M	H
Overall	H	M	H

Content:

1. Single and Multistage Refrigeration: Introduction to refrigeration, applications of refrigeration, development of simple saturated Vapour compression refrigeration cycle, effect of pressure drops, polytropic compression, methods of improvement in the performance of the cycle like sub cooling, superheating, use of heat exchanger etc and working/analysis of multistage systems, multiple evaporator and multiple compressor refrigeration systems. (CO1, CO4)

2. Other Refrigeration Systems: Design and working of Vapor absorption systems (NH3- H20,

LiBr- H2O), Steam jet refrigeration systems, Thermoelectric refrigeration, Vortex tube refrigeration.
(CO1, CO4)
3. Gas Cycle Refrigeration and Cryogenics: Reversed Brayton /Joules/Bell Coleman cycle, aircraft refrigeration, simple cycle, boot strap cycle, reduced ambient cycle, regenerative cycle. Introduction and applications of cryogenics, cascade refrigeration, Joules Thomson coefficient, methods of air liquefaction, Linde's and Claude's cycle, adiabatic demagnetization. (CO1, CO4)
4. Air conditioning: Introduction to air conditioning, psychrometrics, psychrometric processes, comfort and its requirements, comfort chart. (CO2, CO4)
5. Air-conditioning System and duct Design: design of summer air conditioning calculation of dehumidified air quantity and apparatus dew point, ERSHF method, air-conditioning systems for monsoon and winter, principles and methods of duct design.

(CO2, CO4)
6. Components in refrigeration and air conditioning system: compressors, condensers, evaporators, expansion devices, Refrigerants, Air washers, AHU etc, Applications of air conditioning, working of room air-conditioner and split air-conditioner and packaged air-conditioner.
(CO3)

Text Books/ Reference Books:

1. C.P. Arora , 'Refrigeration and air conditioning ',Tata Mcgraw Hill, Third edition,2016
2. P.L Ballaney, ' Refrigeration and air conditioning', Khanna Publishers, 16th edition,2013
3. S. Domkundwar, 'A course in Refrigeration and Air conditioning', Dhanpat rai publication,1980
4. P N Ananthanarayanan , 'Basic Refrigeration and Air Conditioning', McGraw Hill, Fourth edition,2013
5. Pita Edward, 'Air conditioning principles and systems', Prentice hall, 4th edition
6. Randall F Barron, 'Cryogenic systems', Oxford university press', Tata McGraw Hill, 1985.
7. AHRAE handbook -Fundamentals,2017
8. AHRAE handbook –HVAC systems and Equipments,2016
9. Carrier's handbook of Air conditioning system design

MEP438 ADVANCED REFRIGERATION AND AIR CONDITIONING

1 credit (0-0-2)

Pre-requisites: Nil

Overlaps with: Nil

Course Outcomes/ Objectives: Upon successful completion students will be able to:

Upon successful completion students will be able to:

1. understand various theoretical and practical concepts related to single stage refrigeration and for alternate refrigeration systems like vapour absorption, vortex tube and thermoelectric refrigeration to meet PG level requirement.

2. understand practical application of concepts of psychrometrics / psychrometric processes to actual air conditioning machine to meet PG level requirement.
3. Understand working of various equipments/systems used in refrigeration and air conditioning like compressors, condensers, evaporators, expansion devices, controls, refrigerator, air conditioner etc. from post graduate perspective.
4. Understand and apply mathematical treatment to energy efficiency calculations for refrigeration and air conditioning machines to reasonable correctness.

Mapping with POs:

POs → / COs ↓	a	b	c
CO1	H	M	H
CO2	H	M	H
CO3	:H	M	H
CO4	H	M	H
Overall	H	M	H

Content:

1. Experiment on Determination of COP of Refrigeration trainer-**CO1,CO4**
2. Experiment on Determination of COP for Heat pump-**CO1,CO4**
3. Experiment of Determination of COP for Vapour absorption Refrigeration-**CO1,CO4**
4. Experiment of Determination of COP for Thermoelectric Refrigeration- **CO1,CO4**
5. Experiment on Determination of COP for Room air conditioner- **CO3,CO4**
6. Experiment on Determination of COP for Refrigerator- **CO3,CO4**
7. Demonstration of frost free refrigerator-**CO3**
8. Demonstration of conventional Refrigerator-**CO3**
9. Study and demonstration of types of compressors-**CO3**
10. Study and demonstration of types of condensers-**CO3**
11. Study and demonstration of types of evaporators-**CO3**
12. Study and demonstration of types of expansion devices –**CO3**

Text Books/ Reference Books:

1 C.P. Arora , ‘Refrigeration and air conditioning ‘,Tata Mcgraw Hill, Third edition,2016

2 P N Ananthanarayanan , ‘Basic Refrigeration and Air Conditioning’, McGraw Hill, Fourth edition,2013

MEL507 ADVANCED CFD

3 credits (3-0-0)

Pre-requisites: **MEL435** COMPUTATIONAL FLUID DYNAMICS

Overlaps with: NIL

Course Outcomes/ Objectives:

1. To understand the basics of discretization schemes, grid generation, numerical error, and its quantification.

2. To understand the detail CFD algorithms for the incompressible flows and its application to industrial problems.

3. To get proficiency in analysing fluid flow problems and assessing the appropriate CFD techniques to apply for their solution.

4. To solve advanced multi-disciplinary problems involving fluid dynamics and related transport process phenomena.

Mapping with POs:

POs → COs ↓	a	b	c
CO1	M		H
CO2	M		M
CO3	M	M	H
CO4	H	M	H
Overall	M	L	H

Content:

Governing Equations Derivation of Navier-Stokes and energy equations. Physical interpretation of each terms CO1

Discretization Methods Discretization procedure in Finite-volume. Stability analysis, convergence, various discretization schemes. Compact Schemes, high order discretization

CO1

Solution Algorithms Pressure-velocity coupling. Explicit methods: MAC, SMAC. Implicit Methods: SIMPLE, SIMPLER, PISO Matrix inversion methods: direct methods, smooth solver, conjugate gradient method, strongly implicit procedure, Advanced methods: AMG, BiCG, BiCGSTAB Solution methods for various grids CO1,CO2

Grid-Generation: Algebraic, Transfinite, Poisson equation methods. Finite-difference Navier-

Stokes solution on non-orthogonal grids, transformation. Collocated grids. Finite-volume methods on non-orthogonal grids.CO2,CO3

Turbulent flows Boundary layer theory, Introduction to turbulent flows and Reynolds average Navier-Stokes equations (RANS). Turbulent modeling: k-epsilon, k-omega, k-omega SST models based on RANS, LES and DES calculation for internal and external flows. CO3,CO4

Introduction to advanced applications Fluid structure interaction, Flow through porous media, moving frame of reference for turbomachines CO4

Text Books/ Reference Books:

1. Versteeg, H. K. and Malalasekera, W. , "An Introduction to Computational Fluid Dynamics"
2. Hirsh, "Numerical Computation of Internal and External Flows," Vol. 2, Wiley, 1988.
3. Tannehill, and Pletcher , "Computational Fluid Mechanics and Heat Transfer," Second Edition, Taylor & Francis, 1997.
4. Pope, S. B., " Turbulent flows," Cambridge University Press, New York, 2000.
5. Wilcox, D. C. , "Turbulence Modeling for CFD", DCW Industries, La Caada CA, 2000.
6. Tennekes, H. A and Lumley, J. L., "First Course in Turbulence", MIT Press, Cambridge, MA, 1972.

MEL443AIR POLLUTION AND CONTROL

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

1. After attending thecourse the students shall have acquired knowledge and understandingto evaluate air quality management and analyze the causes and effects of air pollution.

2. Students would be able to understand the type and nature of air pollutants, the behavior ofplumes and relevant meteorological determinants influencing the dispersion of air pollutants.

Content:

Introduction: Conventional energy conversion methods using fossil fuels. Their environmental aspects, Pollution from the thermal power plants, thermal and particulate pollution and its control.

IC Engines: Combustion in petrol and diesel engines. Emissions from I.C. Engines and its control. Primary and Secondary Pollutants. Use of various alternative fuels, additives and their effect on pollution.

Conventional and microprocessor based control of Air/Fuel ratio, ignition and injection timing, speed and emissions from I.C.Engines.

Noise pollution: Noise pollution and noise control. Standardization for environmental control pollution

Text Books/ Reference Books:

1. Rao, "Air Pollution", Tata Mc Graw Hill, 7th Edition, 2001
2. Obert E.F., "IC Engines and Air Pollution", Harper & Row Pub, 1979
3. Reston, "Automotive Pollution Control", Reston Pub Co1984
4. Prabhakar V.K, "Air Pollution Monitoring and Control", Anmol Prakashan, 1st Edition, 2001

MEL525 MULTI PHASE FLOW

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with: Nil

Course Outcomes/ Objectives:

Course Objectives

1. This course introduces the fundamental concepts, principles and application of multiphase flow.
2. The course opens with real life examples of such flow and its importance in power generation, nuclear reactor technology, food production, chemical process, aerospace and automotive industries are all driving forces in this complex field.
3. To understand the fluid flow and heat transfer in nuclear reactors.
4. The numerical part will focus on finite-volume methods for Euler-Euler and Euler-Lagrange multiphase flow predictions, and on the associated mathematical models.

Mapping with POs:

POs → / COs ↓	a	b	c
CO1	M	L	L
CO2	H	H	M
CO3	H	M	H
CO4	H	M	H
Overall	H	M	H

Content:

Introduction and definitions: Flow Regimes, Homogeneous Flow, Drift Flux, Separated Flow, Bubbly, Slug, Annular and Stratified Flow, Measurement of Void Fraction. (CO1)

One dimensional steady separated flow model : Flow pattern maps for horizontal and vertical systems; Governing equations for homogeneous, drift-flux, particle trajectory and two-fluid models; Analyses of two-phase flow regimes (CO1 &CO2)

Introduction to computational modeling: Measurement of two-phase flow parameters, Signal Analysis, Two Fluid-Population Balance Technique, Volume of Fluid Method, Lattice Boltzmann Model, Smoothed Particle Hydrodynamics. (CO3)

Measurement techniques for multiphase flow: An introduction to three phase flow, Flow regime identification, pressure drop, void fraction and flow rate measurement. (CO4)

Text Books/ Reference Books:

1.C. Kleinstreuer, Two-Phase Flow: Theory and Applications, Taylor & Francis, Edition 2003.

2. Brennen, C.E, Fundamentals of Multiphase Flow, Cambridge University Press,Edition, 2005.

3.G.B. Wallis, One-Dimensional Two-Phase Flow, McGraw-Hill, Edition, 1969

4. M. Ishii and T. Hibiki, Thermo-Fluid Dynamics of Two-Phase Flow, Springer, 2006

MEL516FUEL CELL TECHNOLOGY

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

1. Introduce to the students different fuel cell technologies available.
2. Impart knowledge to the students regarding reaction kinetics, thermodynamics and heat and mass transfer involved.
3. Predict the performance of the fuel cell theoretically.

Content:

1. Introduction

What Is a Fuel Cell, Fuel Cell Advantages & Disadvantages, Fuel Cell Types : Phosphoric Acid Fuel Cell, Polymer Electrolyte Membrane Fuel Cell, Alkaline Fuel Cell, Molten Carbonate Fuel Cell, Solid-Oxide Fuel Cell, Summary Comparison, Basic Fuel Cell Operation, Fuel Cell Performance, Characterization and Modelling, Fuel Cell Technology, Fuel Cells and the Environment, Life Cycle Assessment, Important Emissions for LCA, Emissions Related to Global Warming, Emissions Related to Air Pollution, Analyzing Entire Scenarios with LCA

2. Fuel Cell Thermodynamics

Thermodynamics Review, Heat Potential of a Fuel: Enthalpy of Reaction, Work Potential of a Fuel: Gibbs Free Energy, Predicting Reversible Voltage of a Fuel Cell under Non-Standard-State Conditions, Fuel Cell Efficiency

3. Fuel Cell Reaction Kinetics

Introduction to Electrode Kinetics, Activation Energy, Reaction Rate, Current Density, Potential of a Reaction, Butler–Volmer Equation, Tafel Equation, Catalyst–Electrode Design

4. Fuel Cell Charge & Mass Transport

Characteristics of Fuel Cell, Charge Transport Resistance, Diffusivity and Conductivity, Mass transport in electrode, Diffusive Transport, Convective Transport

5. Fuel Cell Modelling & Characterization

A Basic Fuel Cell Model, A 1D Fuel Cell Model, Fuel Cell Models Based on Computational Fluid Dynamics, Overview of Characterization Techniques, In Situ Electrochemical Characterization Techniques, Ex Situ Characterization Techniques

6. Overview of Fuel Cell Systems

Fuel Cell Subsystems, Thermal Management Subsystem, Fuel Delivery/Processing

Subsystem, Power Electronics Subsystem, Case Study of Fuel Cell System Design: Sizing a Portable Fuel Cell

Text Books/ Reference Books:

MEP516 FUEL CELL TECHNOLOGY

1 credit (0-0-2)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

Content:

Text Books/ Reference Books:

MEL531BIO ENERGY COVERSION

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

1. The student will be able to understand various definitions and theoretical concepts related to Biomass, Thermochemical Conversion, Biological Conversion, Chemical Conversion, Power generation etc to meet UG level.
2. The student will be able to understand working of various processes/systems used like Techniques for biomass assessment digester design and biogas utilization Hydrolysis & hydrogenation Utilisation of gasifier for electricity generation etc. etc. from undergraduate perspective.
3. The student will be able to apply mathematical treatment to various problems related to to thermo gravimetric analysis and summative analysis, economics of thermo chemical conversion, Economical impacts, transesterification methods to reasonable correctness.

Content:

Biomass: Biomass resources; biomass definition classification and characteristics, availability – estimation of availability, consumption and surplus biomass – energy plantations. Techniques for biomass assessment -Proximate analysis, Ultimate analysis, thermo gravimetric analysis and summative analysis of biomass – briquetting.

Thermochemical Conversion: Different processes, direct combustion, incineration, Biomass pyrolysis –types, slow fast – manufacture of charcoal, methods, yields and application – manufacture of pyrolytic oils and gases, yields and applications., gasification and liquefaction; economics of thermochemical conversion.

Biological Conversion: Biodegradation and biodegradability of substrate; biochemistry and process parameters of biomethanation; chemical kinetics and mathematical modeling of biomethanation process, biogas digester types; digester design and biogas utilisation; economics of biogas plant with their environmental and social impacts; bioconversion of substrates into alcohol: methanol & ethanol production, organic acids, solvents, amino acids, antibiotics etc.

Chemical Conversion: Hydrolysis & hydrogenation; solvent extraction of hydrocarbons; solvolysis of wood; biocrude; biodiesel production via chemical process; catalytic distillation; transesterification methods; Fischer-Tropsch diesel: chemicals from biomass.

Power generation: Utilisation of gasifier for electricity generation; operation of spark ignition and compression ignition engine with wood gas, methanol, ethanol & biogas; biomass integrated gasification/combined cycles systems. Sustainable co-firing of biomass with coal. Biomass productivity: Energy plantation and power programme. Economic impacts; food security and environmental impacts of biomass conversion to energy- energy from waste.

Text Books/ Reference Books:

1. Biofuels - Securing the Planet's Future Energy Needs, Edited by A Demirbas Springer 2009.
2. Biomass Assessment Handbook - Bioenergy for a sustainable environment Edited by Frank Rosillo-Calle, Sarah Hemstock, Peter de Groot and Jeremy Woods, Earthscan November 2006.
3. Biomass Assessment Handbook - Bioenergy for a sustainable environment, Edited by Frank Rosillo-Calle, Sarah Hemstock, Peter de Groot and Jeremy Woods, Earthscan November 2006
4. Dictionary of Renewable Resources - 2nd Edition, Revised and Enlarged, Zoebelein, Hans, Wiley-VCH, 2001.
5. Energy Technology and Directions for the Future, John R. Fanchi, Elsevier Science February 2004.

MEL509 DESIGN & OPTIMIZATION OF THERMAL ENERGY SYSTEMS

3 credits (3-0-0)

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives:

1. The student will be able to understand various definitions and theoretical concepts related to Energy Conservation, Energy Management and Energy Auditing to meet UG level requirement.
2. The student will be able to understand working of variousequipments/systems like Furnaces, Fans and Blowers, Compressors Pumps, Pinch Technology, Fluidized bed Combustion, Heat Exchanger Networks from undergraduate perspective.
3. The student will be able to apply mathematical treatment to various problems related to Energy Efficiency Improvement of Thermal Systems, Energy Conservation, Energy Management and Energy Auditing to reasonable correctness.

Content:

Energy Management : Definition, Scope of energy management, General Principles, Objectives and necessary steps energy management, Energy Manager- Qualifications, Functions, Duties and guidelines, Language. Energy Action Planning, Energy Monitoring and Targeting, Bench Marking,

Energy Auditing : Energy Surveying, Energy Audit - Purpose, Definition and Objectives, Types of Energy Audit-Preliminary and Detailed, Questionnaire Energy Audit Instruments, Thermal Energy measurements, observations, and Data analysis, Energy saving potential.

Energy Conservation: Introduction, Indian Energy Conservation Act, List of Energy Intensive Industries, Rules for Efficient Energy Conservation, Identification of Energy Conservation opportunities, Technologies for Energy Conservation, Energy Conservation Schemes and Measures, Energy flow net works, Critical assessment of energy use. Optimizing Energy Inputs and Energy Balance, Pinch Technology

Energy Efficiency Improvement of Thermal Systems : Steam Generation, Distribution and Utilization, Furnaces, Fans and Blowers, Compressors Pumps, Pinch Technology, Fluidized bed Combustion, Heat Exchanger Net works, Case Studies, analysis and recommendation

Heat Exchangers and Heat Recovery Systems: Heat Exchangers - Classification – Over all heat transfer coefficient, Fouling factor, Design of heat exchangers by L.M.T.D. and N.T.U. methods. Liquid-to-Liquid heat exchangers Shell and tube Heat exchanger. Sources of waste heat , Guidelines to identify waste heat, Grading of waste heat , Feasibility study of waste heat recovery, Gas to Gas and Liquid to liquid heat recovery, waste heat boilers.

Text Books/ Reference Books:

1. Energy Conservation/ Paul O’ Callaghan/ 1981.
2. Energy Management And Conservation /K V Sharma and P Venkataseshaiah
3. Energy Management/ Paul O’ Callaghan/ Mc Graw Hill/ 1992
4. Heat Recovery Systems / D.A.Reay / E and F.N.Spon / 1979
5. Process Heat Transfer by D.Q.Kern
6. Energy Management, / Murphy W.R. and Mckay G/ Butterworth London, 1982
7. Energy Management Principles / Craig B. Smith /Pergamon Press
8. Plant Engineers and Managers guide to Energy Conservation /Albert Thumann / Nost and Reinhold Co., New York.

MED502 Project Phase II

9 credits

Pre-requisites: Nil

Overlaps with:

Course Outcomes/ Objectives: Students will be able

1. To identify research problem
2. To review literature
3. To present research report
4. To carry out scientific investigation

Mapping with POs*:

POs → COs ↓	PO1	PO2	PO3
CO1	L	M	M
CO2	M	M	M
CO3	H	H	H
CO4	H	H	H
Overall	H	H	H

Content

Text Books/ Reference Books: