AC-6.6.2012
Item No. 4.60

UNIVERSITY OF MUMBAI

Syllabus for the M. E. Program

Program: M. E. (Mechanical Engineering)

HEAT POWER

(As per Credit Based Semester and Grading System introduced with effect from the academic year 2012–2013)

Ordinances & Regulations are applicable as per M.E. Mechanical Engg.

Program Structure for
ME Mechanical Engineering (Heat Power)
Mumbai University

(With Effect from 2012-2013)

Semester I

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
HPC101	Numerical methods in Heat Transfer and fluid flow	04	--	--	04	--	--	04
HPC102	Advance Thermodynamics	04	--	--	04	--	--	04
HPC103	Energy conservation & Financial Management	04	--	--	04	--	--	04
HPE101X	Elective I	04	--	--	04	--	--	04
HPE102X	Elective II	04	--	--	04	--	--	04
HPL101	Laboratory I – Computational Fluid Dynamics	--	02	--	--	01	--	01
HPL102	Laboratory II - Refrigeration & Air conditioning Technologies	--	02	--	--	01	--	01
Total		**20**	**04**	--	**20**	**02**	--	**22**

Subject Code	Subject Name	Examination Scheme							
		Theory					Term Work	Pract. /oral	Total
		Internal Assessment			End Sem. Exam.	Exam. Duration (Hrs.)			
		Test1	Test2	Avg.					
HPC101	Numerical methods in Heat Transfer and fluid flow	20	20	20	80	03	--	--	100
HPC102	Advance Thermodynamics	20	20	20	80	03	--	--	100
HPC103	Energy conservation & Financial Management	20	20	20	80	03	--	--	100
HPE101X	Elective I	20	20	20	80	03	--	--	100
HPE102X	Elective II	20	20	20	80	03	--	--	100
HPL101	Laboratory I – Computational Fluid Dynamics	--	--	--	--	--	25	25	50
HPL102	Laboratory II – Refrigeration& Air conditioning Technologies	--	--	--	--	--	25	25	50
Total		--	--	**100**	**400**		**50**	**50**	**600**

Subject Code	Elective I	Subject Code	Elective II
HPE1011	Refrigeration and Air conditioning Technologies	HPE1021	Conventional Power plants
HPE1012	Advanced Internal Combustion Engines	HPE1022	Advanced Gas Dynamics
HPE1013	Alternative Fuels for I.C Engines	HPE1023	Computational Fluid Dynamics

Semester II

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
HPC201	Advance Heat & Mass Transfer	04	--	--	04	--	--	04
HPC202	Advanced Fluid Mechanics	04	--	--	04	--	--	04
HPC203	Instrumentation & control systems	04	--	--	04	--	--	04
HPE203X	Elective III	04	--	--	04	--	--	04
HPE204X	Elective IV	04	--	--	04	--	--	04
HPL203	Laboratory III - Modelling& Simulation of IC Engines	--	02	--	--	01	--	01
HPL204	Laboratory IV – Computational Heat Transfer and fluid flow	--	02	--	--	01	--	01
Total		**20**	**04**	--	**20**	**02**	--	**22**

Subject Code	Subject Name	Examination Scheme							
		Theory					Term Work	Pract. /oral	Total
		Internal Assessment			End Sem.Exam.	Exam. Duration (Hrs.)			
		Test1	Test 2	Avg.					
HPC201	Advance Heat & Mass Transfer	20	20	20	80	03	--	--	100
HPC202	Advanced Fluid Mechanics	20	20	20	80	03	--	--	100
HPC203	Instrumentation & control systems	20	20	20	80	03	--	--	100
HPE203X	Elective III	20	20	20	80	03	--	--	100
HPE204X	Elective IV	20	20	20	80	03	--	--	100
HPL203	Laboratory III - Modelling& Simulation of IC Engines	--	--	--	--	--	25	25	50
HPL204	Laboratory IV – Computational Heat Transfer and fluid flow	--	--	--	--	--	25	25	50
Total		--	--	**100**	**400**	--	**50**	**50**	**600**

Subject Code	Elective III	Subject Code	Elective IV
HPE2031	Cryogenics	HPE2041	Design & performance of Heat Exchanger
HPE2032	Modelling& Simulation of IC Engines	HPE2042	Computational Heat Transfer
HPE2033	Cogeneration and Waste Heat Recovery System	HPE2043	Non Conventional Power Plants

Semester III

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
HPS301	Seminar	--	06	--	--	03	--	03
HPD301	Dissertation I	--	24	--	--	12	--	12
Total		**--**	**30**	**--**	**--**	**15**	**--**	**15**

Subject Code	Subject Name	Examination Scheme						
		Theory				Term Work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.			
		Test1	Test 2	Avg.				
HPS301	Seminar	**--**	**--**	**--**	--	50	50	**100**
HPD301	Dissertation I	**--**	**--**	**--**	--	100	--	**100**
Total		**--**	**--**	**--**	**--**	**150**	**50**	**200**

Semester IV

Subject Code	Subject Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
HPD401	Dissertation II	--	30	--	--	15	--	15
Total		**--**	**30**	**--**	**--**	**15**	**--**	**15**

Subject Code	Subject Name	Examination Scheme						
		Theory				Term Work	Pract./ Oral	Total
		Internal Assessment			End Sem. Exam.			
		Test1	Test 2	Avg.				
HPD401	Dissertation II*	**--**	**--**	**--**	--	100	100	**200**
Total		**--**	**--**	**--**	**--**	**100**	**100**	**200**

* The Term Work and Oral of Dissertation II of Semester IV should be assessed jointly by the pair of Internal and External Examiners

Note- The Contact Hours for the calculation of load of teacher are as follows
Seminar - 01 Hour / week / student
Project I and II - 02 Hour / week / student

Subject Code	Subject Name	Credits
HPC101	**Numerical Methods in Heat Transfer and Fluid Flow**	**04**

Module	Detailed content	Hours
1	**Linear Algebraic Equations**: Gauss – Elimination, Gauss – Seidel, LU Decomposition.	06
2	**Roots of equations**: Bisection Method, False position method, Newton – Raphson Method, Muller's method, Bairstow's Method. **Curve fitting**: i) Linear regression, multiple linear regressions, polynomial regression. ii) Non linear regression – Gauss – Newton method, multiple non linearregression.	10
3	**Ordinary differential equations:** Euler's method, Heun's method, Mid – point method, Runge – Kutta methods, Multi step Methods - explicit Adams – Bashforth technique & Implicit Adams – Moulton Technique, Adaptive RK method, Embedded RK method, step size control. Higher order ODE – Shooting method. Non linear ODE – Collocation technique.	12
4	**Partial Differential Equations:** Solution of Parabolic and Hyperbolic equations – Implicit & Explicit Schemes, ADI methods, Non linear parabolic equations- Iteration method. Solution of elliptic equation – Jacobi method, Gauss – Seidel & SOR method. Richardson method.	10
5	**Overview of numerical methods:** Finite Element Methods, Finite Difference Methods, Finite Volume Methods in heat transfer and Fluid Flow. Discretised representation of physical systems - thermal resistance, flow resistance networks, thermal capacitance – Governing equations and boundary conditions for thermal and flow systems.	10
	Finite Element Method: FEM in one dimensional heat conduction, principles of variations calculus - applications of variation approach to one dimensional heat conduction - element matrix contribution and assembly. **FEM and FDM in flow problems:** Incompressible laminar flow simulation – Stream function / Vorticity methods, Velocity Pressure formulation, mixed order interpolation for incompressible flow, modifications for turbulent flow.	12

References:-

1. Numerical Methods for Engineers, Steven C Chapra& Raymond P Canale, TMH, Fifth Edition
2. Numerical Solution of Differential Equations, M.K. Jain, 2nd Edition, Wiley Eastern.
3. Numerical methods for scientific and engineering computation, Jain, Iyangar, Jain, New Age International Publishers.
4. Numerical methods in Engineering and Science, Dr. B.S. Garewal, Khanna Publishers.
5. Carnanan. B., Luther. H.A., and Wilkes, J.O., Applied Numerical Methods, WileyandSons,1976.
6. S.S.RaoPergamon ,The Finite Element Method in Engg., 2nd ed, Pergamon Press,
7. Larry Segerlind, Applied Finite Element Analysis, 2nd ed John Wiley & Sons, 1988.
8. J.N. Reddy, Finite Elements Methods, McGraw-Hill 1988.
9. Daryl L. Logan, A First Course in the Finite Element Method, Thomsen Education.
10. Comini,Gianni,Nonino,Car,Finite Element Analysis in Heat Transfer: BasicFormulation and Linear Problems, Taylor & Francis.
11. Ghoshdasdidar, P.S., "Computer Simulation of flow and heat transfer" Tata McGraw-Hill Publishing Company Ltd., 1998.

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End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students.Minimum 80%syllabus should be covered in question papers of endsemester examination.

Subject Code	Subject Name	Credits
HPC102	**Advanced Thermodynamics**	**04**

Module	Detailed content	Hours
1	**Introduction**: Availability, Irreversibility and Second-Law Efficiency for a closed System and steady-state, control Volume. Availability Analysis of Simple Cycles. Thermodynamic Potentials, Maxwell relations, Generalized relation for changes in Entropy, Internal Energy and Enthalpy.	08
2	**Equation of State:** State postulate for Simple System and equation of state, Ideal gas equation, Deviationfrom ideal gas, Equation of state for real gases, generalized Compressibility chart,Law of corresponding states. Different Equations of State, Fugacity, Compressibility, Principle of CorrespondingStates, Use of generalized charts for enthalpy and entropy departure, fugacity coefficient,Lee-Kesler generalized three parameter tables.	10
3	**Laws of thermodynamics:** 2nd law Analysis for Engineering Systems, Entropy flow &entropy generation, Increase of entropy principle, entropy change of pure sub, T-dsrelations, entropy generation, thermo electricity, Onsager equation. Exergy analysisof thermal systems, decrease of Exergy principle and Exergy destruction.	10
4	**Properties of Pure Substances**: Phase change process of pure substances, PVT surface, P-v &P- T diagrams, Use ofsteam tables and charts in common use **Thermodynamic Property Relations**: Partial Differentials, Maxwell relations, Clapeyron equation, general relations for du,dh, ds, and Cv and Cp, Joule Thomson Coefficient, _h, _u, _s of real gases.	10
5	**Chemical Thermodynamics**: Chemical reaction, Fuels and combustion, Enthalpy of formation and enthalpy ofcombustion, First law analysis of reacting systems, adiabatic flame temperature, Chemical and Phase equilibrium - Criterion for chemical equilibrium, equilibriumconstant for ideal gas mixtures, some remarks about Kp of Ideal-gas mixtures,fugacity and activity, Simultaneous relations, Variation of Kp with Temperature,Phase equilibrium, Gibb's phase rule, Third law of thermodynamics, Nerst heattheorem and heat death of universe	12
6	**Gas Mixtures** – Mass & mole fractions, Dalton's law of partial pressure, Amagat'slaw, Kay's rule. **Statistical Thermodynamics-** Fundamentals, equilibrium distribution, Significance ofLagrangian multipliers, Partition function for Canonical Ensemble, partition functionfor an ideal monatomic gas, equi-partition of energy, Bose Einstein statistics, Fermi-Dirac statistics.	10

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References:

1. Cengel, Thermodynamics, TMH
2. Howell &Dedcius: Fundamentals of engineering Thermodynamics, McGraw Hill,Inc, USA
3. Van Wylen& Sontag: thermodynamics, John Wiley & Sons, Inc.,USA
4. Holman, Thermodynamics, 4th edition, McGraw Hill
5. Zimmansky&Dittman, Heat and Thermodynamics, 7th edition, TMH
6. Rao, Y.V.C., Postulational and Statistical thermodynamics, Allied Pub. Inc.
7. Jones and Hawkings: engineering Thermodynamics, john Wiley & Sons, Inc. USA
8. Faires V. M. and Simmag: Thermodynamics. McMillan Pub. Co. Inc. USA
9. Turns, Thermodynamics- Concepts and Applications, Cambridge University Press
10. Wark, Advanced Thermodynamics, McGraw Hill
11. Nag P.K., Basic & Applied Thermodynamics, TMH, New Delhi.
12. Jones &Dugan, Advanced Thermodynamics, Prentice Hall Int.
13. Bejan, Advanced Thermodynamics, John Wiley, Inc.
14. Kenneth WarkJr.,Advanced Thermodynamics for Engineers, McGraw-Hill Inc., 1995.
15. DeHotf,R.T. Thermodynamics in Materials Science, McGraw-Hill Inc.,
16. Winterbone DE, Advanced thermodynamics for engineers, Arnold 1997.
17. Sonntag, R.E., and Vann Wylen, G, Introduction to Thermodynamics, Classical and Statistical, third Edition, John Wiley and Sons, 1991.

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Subject Code	Subject Name	Credits
HPC103	**Energy Conservation and Financial Management**	**04**

Module	Detailed content	Hours
1	**Introduction:** The energy market, sources of world energy, exhaustible and renewable / inexhaustible sources, energy scenario in India, energy planning, utilization pattern and future strategy, Energy conservation Act 2003. Importance of energy management. Energy auditing: methodology analysis of post trends (plant data), closing the energy balance, laws of thermodynamics, measurements, portable and online instruments.	10
2	**Steam Systems**: Boiler-efficiency testing, excess air control, steam distribution and use of steam traps, condensate recovery, flash steam utilization, thermal insulation. Performance Energy conservation in pumps, Fans & Compressors, Air conditioning and refrigeration systems, Steam Traps- Types, Function, Necessity.	10
3	**Electrical Systems:** Demand control, power factor correction, load scheduling / shifting, motor drives, motor efficiency testing, energy efficient motors, motor speed control. Demand side management, Electricity Act 2001. Lighting: Lighting levels, efficient options, fixtures, day lighting, timers, energy efficient windows.	10
4	**Energy Management:** Cogeneration: Concept options (steam / gas / turbine / diesel engine bases), selection criteria, control strategy. Energy economics – discount rate, payback period, and internal rate of return, life cycle costing.	08
5	**Engineering Economic Analysis:** Basic concepts & price theory, Supply & Demand, Consumer behavior, Law of reducing returns, Competition- types, equilibrium, Inflation & unemployment, Foreign trade, Balance of payment.	10
6	**Finance:** Functions, source of finance, National & International finance, Benefits & Limitations, Budgets & Budgeting Control. **HR Management:** Difference between personnel management & HR management, Role of HR Manager, Manpower planning, Merit rating, Training & Development, Retirement & Separation, Organizational Development &Behaviour, Management by objectives.	12

References:

1. CB Smith, Energy Management Principles, Pergamon Press, NewYork, 1981
2. Hamies, Energy Auditing and Conservation; Methods, Measurements, Management &Case study, Hemisphere, Washington, 1980
3. Trivedi, PR, Jolka KR, Energy Management, Commonwealth Publication, New Delhi, 1997
4. Witte, Larry C, Industrial Energy Management & Utilization, Hemisphere Publishers, Washington, 1988
5. Diamant, RME, Total Energy, Pergamon, Oxford, 1970.
6. S C Kuchal, Indian Economics
7. Collin Drury, Management & Cost Accounting, English Language Book Series, Chapman & Hall, London [ISBN 0412 341204]
8. E Dessler, Human Resource Management
9. R S Dwivedi, Managing Human Resporces
10. B S Sahay, World Class Manufacturing
11. Fred Luthans, McGraw Hill Publications, Organizational Behaviour
12. Robbins S P, Prentice Hall Publications, Organizational Behaviour

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Subject Code	Subject Name	Credits
HPE1011	**Refrigeration and Air Conditioning Technologies**	**04**

Module	Detailed content	Hours
1	**Refrigeration Technology:** **Vapour Compression refrigeration**: Multi-evaporator system; Multi expansion system; Cascade systems; Study of P-h; T-s; h-s and T-h charts for various refrigerants, Concept of Heat Pump.	08
2	**Vapour absorption refrigeration**: Standard cycle and actual cycle, thermodynamic analysis, Li-Br-water, NH_3-water systems, Three fluid absorption systems, half effect, single effect, single-double effect, double effect, and triple effect system Non-convention refrigeration system (Principle and thermodynamic analysis only): Thermoelectric refrigeration, thermo-acoustic refrigeration, adsorption refrigeration, steam jet refrigeration, vortex tube refrigeration, and magnetic refrigeration.	10
3	**System Components & Accessories**: Types of Evaporators, Compressors, Condensers, Functional Aspects of the above components & accessories: Expansion Devices, Driers/ Filters, high pressure receiver thermal design of low pressure receiver, Accumulator, oil separators, relief valves, safety valves, high and low pressure cut out, thermostats, water regulators etc.	08
4	**Air Conditioning Technology:** **Load Estimation and Air Distribution**: solar heat gain, study of various sources of the internal and external heat gains, heat losses, etc. Methods of heat load calculations: Equivalent Temperature Difference Method, Cooling Load Temperature Difference, and Radiance Method, RSHF, GSHF, ESHF, etc. Inside and outside design conditions. Fundamentals of air flow in ducts, pressure drop calculations, design ducts by velocity reduction method, equal friction method and static regain method, duct materials and properties, insulating materials, types of grills, diffusers, wall registers, etc.	12
5	**Ventilation and Infiltration**: Requirement of ventilation air, various sources of infiltration air, ventilation and infiltration as a part of cooling load. **Fans and Blowers**: Types, performance characteristics, series and parallel arrangement, selection procedure. **Air Conditioning Equipments and Controls**: Chillers, Condensing units, Cooling coils, bypass factors, humidifiers, dehumidifiers, various types of filters, air washers, thermostat, humidistat, cycling and sequence controls, modern control of parity, odour and bacteria, Air filtration- Study of different types of filters, BMS applications. Cooling Towers.	10

6	**Direct and Indirect Evaporative Cooling and Air conditioning systems**: Basic psychometric of evaporative cooling, types of evaporative coolers, design calculations, indirect evaporative cooling for tropical countries. Classification, design of central and unitary systems, typical air conditioning systems such as automobile, air plane, ships, railway coach air-conditioning, warm air system, hot water systems, heat pump, clean rooms (descriptive treatments only). **Standards and Codes**: ASHRAE/ARI, BIS standards study and interpretation, ECBC, NBC codes. Case studies to be dealt with selection and design of various components for various Industrial refrigeration applications: Cold storage, Process applications - textile, pharmaceuticals, chemical, transport, etc.	12

References:

1. R.J. Dossat, Principles of refrigeration, Pearson Education Asia
2. C.P. Arora, Refrigeration and Air-Conditioning
3. Stoecker and Jones, Refrigeration and Air-conditioning
4. Jordan and Priester, Refrigeration and Air-conditioning
5. A.R. Trott, Refrigeration and Air-conditioning, Butterworths
6. J.L. Threlkeld, Thermal Environmental Engineering, Prentice Hall
7. W.F. Stoecker, Industrial Refrigeration Handbook, McGraw-Hill
8. Langley, Billy C., 'Solid state electronic controls for HVACR' pentice-Hall 1989.
9. John A. Corinchock, Technician’s guide to Refrigeration systems, McGraw-Hill
10. P.C. Koelet, Industrial Refrigeration: Principles, design and applications, McMillan.
11. Handbook of Air Conditioning System Design, Carrier Incorporation, McGraw Hill Book Co., USA.
12. Trane air conditioning manual,
13. Norman C. Harris, Modern air conditioning
14. Jones W. P., Air conditioning Engineering - Applications, Edward Arnold Publishers Ltd, London, 1984
15. Hainer R. W., Control System for Heating, Ventilation and Air conditioning, Van
16. Nastrand Reinhold Co., New York, 1984.
17. ASHRAE Handbooks
18. ISHRAE Handbook.
19. ARI Standards
20. Refrigeration Handbook, Wang, McGraw Hill, Int.

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Subject Code	Subject Name	Credits
HPE1012	**Advanced Internal Combustion Engines**	**04**

Module	Detailed content	Hours
1	**Spark Ignition Engines:** Mixture requirements, Fuel Injection systems,Monopoint,Multipoint injection, Direct injection, Stages of combustion, Normal and abnormal combustion, Factors affecting knock, Combustion chambers.	08
2	**Compression ignition engines:** Stages of combustion in C.I. Engine, Direct and indirect injection systems, Combustion chambers, Fuel spray behavior, spray structure, spray penetration and evaporation, air motion, Turbo charging and supercharging. **Combustion modeling**: Basic concepts of engine simulation, governing equations, simulation of various engine processes for SI and CI Engines. Thermodynamic and fluid mechanic based models.	12
3	**Measurement & Testing:** Introduction, engine performance parameters, measurement and testing, engine operating characteristics, performance maps. **Engine Materials:** Various engine components, cylinder head, spark plug, gaskets, cylinder block, piston, piston rings, gudgeon pin,connecting rod, crankshaft, bearings, crankcase, fuel injector.	10
4	**Engine friction and lubrication:** Measurement of friction, fluid mechanics based multidimensional models, Engine operating characteristics. **Engine Design:** Preliminary analysis, cylinder number, size and arrangement, experimental development. **Electronic Injection System:** Gasoline injection, EFI system, MPFI system, electronic control system,injection timing, electronic diesel injection system and control.	10
5	**Engine Emissions & Control:** Air pollution due to IC engines, norms, engine emissions, HC, CO, NOx,particulates, other emissions, emission control methods, exhaust gas recirculation, modern methods.	08
6	**Simulation Technique:** Application of simulation technique for engine tuning, engine selection parameters, recent trends in IC engines. **Recent trends:** Lean Burn Engines, Stratified charge Engines, homogeneous charge compression ignition engines, Plasma Ignition, Zero Emission Vehicles, Engines for special applications, Mining, Defense, Off-highway -Tractor, Bulldozer etc. Submarines, Race car Engine systems, Flexible fuel systems. Surface ignition.	12

References:

1. Taylor, C.P., The Internal Combustion Engines in Theory and Practice, Vol-2, MIT press, 1985.
2. John B Heywood, Internal Combustion Engine Fundamentals, McGraw Hill
3. M.L. Mathur and R.P.Sharma, A course in internal Combustion Engines, DhanapatRaiPublications, New Delhi.
4. V. Ganesan, Int. Combustion Engines, II Edition, TMH, 2002.
5. Duffy Smith, Auto fuel Systems, The Good Heart Willox Company, Inc.
6. Ganesan V. Computer simulation of spark ignition process: University process. Hyderabad 1993.
7. Ganesan V. Computer simulation of compression ignition engine. Orient Long man, 2000.

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Subject Code	Subject Name	Credits
HPE1013	**Alternative Fuels For I.C Engines**	**04**

Module	Detailed content	Hours
1	**Alternative fuels**: Alcohol, Hydrogen, Natural Gas Bio diesel, fuel cell. Other possible fuels and Liquefied Petroleum Gas- Properties, Suitability, Merits and Demerits as fuels, Engine Modifications.Dual fuel operation.	10
2	Availability and Suitability to Piston Engines, Concept of conventional fuels, potential alternative fuels-Alcohol, Methanol, DEE/DME-Hydrogen, LPG, Natural gas, Producer gas, Bio-gas and vegetable oils-Use in IC engines-Merits and demerits of various fuels.	10
3	Technical Background of Diesel/Bio-diesel fuels-Oil feed stocks-Transesterification-Bio-diesel production from Vegetable oils and waste cooking oil-High blend levels of bio-diesel-Testing Bio diesel-Oxidation stability-Performance in Engines, Properties of bio-fuels and their importance in the context of IC Engines.	10
4	Initiation of combustion, flame velocities, Normal and abnormal combustion, Knocking combustion, pre-ignition-Knock and engine variables,-Features and design consideration of combustion chambers-stratified charge combustion- concepts of lean burn engines. Computation of heat release rates from cylinder pressure data. Spray formation and combustion in diesel engines. Heat release and heat transfer correlations for diesel engines.	12
5	Types-Air flow, Fluid flow, Temperature, Speed, Oxygen, Detonation, Position, Principle of operation, Arrangement and material. Cylinder pressure measurement.	08
6	Atmospheric pollution from piston engines, Global warming, Pollutant Formation in IC Engines- Emission measurement-control of Engine pollution–driving cycles and Emissionstandards. Emission measuring instrumentation including HC, CO, NOx, smoke and particulates.	10

References:

1. John B. Heywood, *Internal Combustion Engine Fundamentals*, McGraw Hill Book Company, 1988.
2. Taylor, C.P., *The Internal Combustion Engines in Theory and Practice*, Vol-2, MIT press, 1985.
3. RichardL.Bechtold, *Automotive Fuels Guide Book*, SAE Publications, 1997.

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Subject Code	Subject Name	Credits
HPE1021	**Conventional Power Plant**	**04**

Module	Detailed content	Hours
1	**Introduction:** Energy reserves and Energy utilization the world– Electrical Power Generation & Consumption in India. Types of Power Plants Merits and Demerits – Criteria for Selection of Power Plants.	10
2	**Steam Turbines**: Power plant cycles, Layout, Super Heaters, Re-heaters, Condensers Economizers and Feed Water heaters, Operation and performance, Rankine cycle with Super Heat, Reheat and Regeneration cycle analysis and design losses in steam turbines, Performance at various loads, governing, operation and management. Fluidized Bed combustion boiler,Fluidized bed combustion, sizing of power plant components: steam generator, condenser, cooling tower, turbines Advantages, waste heat Recovery boilers: Co – generation Power Plant - Emissions and their controls.etc.	12
3	**Nuclear Power plant**: Overview of Nuclear Power Plant, Nuclear physics Radio activity,fission process Reaction Rates, diffusion theory, Critical heat flux, Nuclear Power Reactors, different types, advantages and limitations, Materials used for Reactors. Hazards in Nuclear Power Plant, Remedial Measures - Safety precautions, Methods of Waste disposal Different form of Waste from Power Plant.	10
4	**Combined cycle power plants:** Binary vapour cycles, Coupled cycles, Combined Power cycle Plants, Advantages and Limitations, Gas turbine, Steam turbine Power Plant And MHD, Steam Power Plant., Combustor, pollution control techniques, diesel engine power plants.	08
5	**Gas Turbine and MHD Power Plant** Layout of Gas Turbine - Basic Gas turbine cycle, cycle improvements, Intercoolers, Re-heaters and regenerators, Thermodynamic analysis of Gas turbine, Operations and performance of Gas Turbine Layout of MHD Power Plant, Principles of Working, Function and Important of Individual Component, salient features, Hydropower and its constraints, environmental and social impacts, selection of components, Mini and micro Hydal power plants.	10
6	**Energy storage**: Need, different systems, thermal storage, hybrid air storage systems, fuel cell, latent heat storage systems, hydrogen energy systems etc. Instrumentation systems used, clean energy technology, projection of energy demands and planning of different plants, load management. Environment and social impact, Economic feasibility of power plants, Fuel substitutions, Safety in power plants.	10

References:

1. Power plant Engineering: P.K.Nag, Tata McGraw Hill, III edition, 2007.
2. An Introduction to Power plant engineering, G.D.Rai, Khanna Publishers, III edition, 2001
3. Hydropower development series, Vol.1-17, Norwejian Institute of Technology, 1996/2005.
4. Combined cycle Gas and Steam Turbine Power Plants, Rolf H Kohlhofer, Penn WellBooks, 1991
5. Power Plant Engineering Technology – M.M. Wakil – McGraw - Hill
6. Steam Plant operation – by Everett B. Woodruff Lammers, Thomas F. Lammers –McGraw – Hill
7. Standard Hand Book of Power Plant Engineering – by Thomas C. Elliott, Kao Chenand Robert C.Swamekamp – McGraw– Hill

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End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students.Minimum 80%syllabus should be covered in question papers of endsemester examination.

Subject Code	Subject Name	Credits
HPE1022	**Advanced Gas Dynamics**	**04**

Module	Detailed content	Hours
1	**Review of Elementary Principles:** Mathematical Concepts, Thermodynamic Concepts for Control Mass Analysis. **Control Volume Analysis** Flow Dimensionality and Average Velocity, Transformation of Material Derivative to a Control Volume Approach, Conservation of Mass, Conservation of Energy, Comments on Entropy, Pressure-Energy Equation, The Stagnation Concept, Stagnation Pressure-Energy Equation, Consequences of Constant Density.	10
2	**Introduction to Compressible Flow** Sonic Velocity and Mach Number, Wave Propagation, Equations for Perfect Gases in terms of Mach Number, h-s and T-s Diagrams. **Varying Area Adiabatic Flow** General Fluid Flow without Losses, Perfect Gas Flow with Losses, Isentropic Table, Nozzle operation and performance, Diffuser performance.	10
3	**Standing Normal Shocks** Shock analysis for general fluid, Working equations for perfect gases, Normal Shock table, Shocks in Nozzles, Supersonic wind tunnel. **Moving and Oblique Shocks** Normal velocity superposition: Moving normal shocks, tangential velocity superposition: Oblique shocks, oblique shock analysis of perfect gas, oblique shock table and charts, Boundary condition of flow direction, Boundary condition of pressure equilibrium, Conical shocks.	10
4	**Prandtl-Meyer Flow** Argument for isentropic turning flow, Analysis of Prandtl–Meyer flow, Prandtl-Meyer function, over expanded and underexpanded nozzles, supersonic airfoils. **Fanno Flow** Analysis for a General fluid, Working equations for perfect gases, reference state and Fanno table, applications, correlation with shocks, friction chocking.	10
5	**Rayleigh Flow** Analysis for a general fluid, Working equations for perfect gases, reference state and Rayleigh table, applications, correlation with shocks, thermal chocking due to heating.	12
6	**Real Gas Effects** Behavior of real gases, Equations of states and compressibility factors, semi perfect gas behavior.	08

References:

1. Zucker R. D. and Biblarz Oscar, “Introduction to Gas Dynamics”, John Wiley and Sons. Inc., Second Edition [2002]
2. A. H. Shapiro, “Dynamics and Thermodynamics of Compressible Fluid Flow”, MIT Press.
3. Zucrow, “Gas Dynamics”, Vol I, and Vol. II, John Wiley and Sons Inc, New York.
4. S. M. Yahya, Gas Dynamics and Jet Propulsion.

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Subject Code	Subject Name	Credits
HPE1023	**Computational Fluid Dynamics**	**04**

Module	Detailed content	Hours
1	**Introduction to CFD and the Governing Equations of Fluid Dynamics:** Historical background, Impact of CFD, Derivation, Discussion of physical meanings and Presentation of forms particularly suitable to CFD.	08
2	**Basic Aspects of Discretization:** Introduction to Finite Difference, Finite Elements and Finite Volume Methods.Detailed treatment of Finite Difference method, explicit and implicit methods, errors and stability analysis. **Grids with Appropriate Transformations** Adaptive grids and unstructured meshes. Uniform and non-uniform Grids, Numerical Errors, Grid IndependenceTest.	10
3	**Few CFD Techniques** The Lax-Wendroff Technique, MacCormack's Technique, Space marching, Relaxation Technique, Numerical dissipation and dispersion, Artificial viscosity, The ADI Technique, Pressure correction Technique: Application to incompressible viscous flow, the SIMPLE algorithm. SIMPLE Procedure of Patankar and Spalding, Computation of Boundary layer flow, Finite deference approach.	10
4	**Numerical Solution of Governing equations:** Numerical solution of elliptical equations - Linear system of algebraic equations – Iterative solution of system of linear equation. Model Equations, Wave equations, Numerical solution of parabolic equations, Stability analysis,Advanced shock capturing schemes. Solutions of convection, Diffusion equation, Conservative and non-conservative schemes, concept of artificial viscosity and Numerical Diffusion.Navier-Stokes equations and algorithms; Basics of grid generation, Numerical solution ofhyperbolic equations - Burgers equation generation.	12
5	**Convection Heat Transfer And FEM**: Steady One-Dimensional and Two-Dimensional Convection - Diffusion, Unsteady one-dimensional convection - Diffusion, Unsteady two-dimensional convection - Diffusion - Introduction to finite element method - Solution of steady heat conduction by FEM - Incompressible flow - Simulation by FEM.	10
6	**Incompressible Couette Flow** Solution by implicit method and the pressure correction method, Governing Equations, Stream Function - Vorticity method, Determination of pressure for viscous flow, **Turbulence Models**: Algebraic Models - One equation model, K-I Models, Standard and High and Low Reynolds number models, Prediction of fluid flow and heat transfer using standard codes. **Numerical Solution of a 2D Supersonic Flow** Prandtl-Meyer Expansion Wave **Supersonic Flow over a Flat Plate** Numerical Solution by solving complete Navier Stokes equation.	10

References:

1. John D. Anderson Jr., “Computational Fluid Dynamics-The Basics with Applications”, McGraw Hill. Inc.,
2. Fletcher C.A.J. “Computational Techniques for Fluid Dynamics”, Volumes I and II, Springer, Second Edition [2000].
3. C. Hirsch, “Numerical Computation of Internal and External Flows”, Volumes I and II, John Wiley & Sons [2001]
4. Tannehill J. C., Anderson D.A., and Pletcher R.H., Computational Fluid Mechanics and Heat Tran5fer, 2nd ed., Taylor & Francis, 1997.
5. Hoffmann, K.A. and Chiang, S.T., Computational Fluid Dynamics for Engineers, Engineering Education Systems, 2000.
6. Peyret, R. and Taylor, T. D., Computational Methods for Fluid Flow, Springer-Verlag, 1983.
7. Muralidhar K.andSundararajanT., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi1995.
8. Ghoshdasdidar P.S.,"Computer Simulation of flow and heat transfer" Tata McGraw-Hill Publishing Company Ltd., 1998.
9. Subas, V.Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation
10. Taylor, C and Hughes J.B.,Finite Element Programming of the Navier Stock Equation, Pineridge Press Ltd., U.K.1981.

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Subject Code	Subject Name	Credits
HPL101	**Computation Fluid Dynamics**	**01**

Module	Detailed content	Hours
1	**Simulation study using mathematical simulation software (or any programming language) on** • Steady State Conduction in Solid • Steady State Convection in Solid • Steady State Radiation in Solid	05
2	**Simulation study using finite element software on** • Combined conduction and convection • Unsteady state conduction and convection • Unsteady state conduction and radiation	05
3	**Simulation study using FEM, FDM and FVM** • Steady state conduction in Fluids • Steady state convection in Fluids • Two-phase flows • Condensation and boiling heat transfer	05

Note: Software should be used Fluent /Star CD/ ANSYS/CFX / user defined codes.

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
HPL102	**Refrigeration and Air Conditioning Technologies**	**01**

Module	Detailed content	Lab. Sessions
1	• Trial on VCC as Heat pump • Trial on VCC- Effect of condensing and evaporator temperature on Performance	03
2	• Design of Vapor Absorption System 100 kW or 200 kW or 300 kW etc. • Design Project for system selection, load estimation, duct design, equipmentselection, Control systems, cost estimation, lay out diagrams (line sketches) for anyone application from: Hospital, Hotel, Auditorium, Computer lab, Operation Theateretc. • Draw Psychrometric chart for a non-standard Pressure	07
3	• Visit report on (Any Two) (a) Cold Storage (b) Ice Plant (c) Dairy (d) Pharmaceutical	05

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
HPC201	**Advanced Heat & Mass Transfer**	**04**

Module	Detailed content	Hours
1	**Introduction:** Overview of the subject of heat transfer with orientation to applications, the various boundary conditions.Analytical solutions for temperature distribution.Concept of thermal resistance, contact resistance. Problems related to anisotropic materials.Extended surfaces, Steady state analysis and optimization, Radial fins of rectangular and hyperbolic profiles, longitudinal fin of rectangular profile radiating to free space. **3D heat conduction equations:** 3D heat conduction equations by varying thermal conductivity, Analytical and semi analytical solutions, Transient heat conduction - Exact solution, Lumped Analysis – Heisler's chart, extended surface-geometric non - linear heat transfer-Bessel function.Conduction with moving boundaries.	10
2	**Radiation**: Fundamental concepts, Radiation Intensity: Relation to emission, irradiation and radiosity. Black body radiation and associated laws. Spherical and hemispherical properties. Environmental radiation, Radiation exchange between surfaces, the view factor, black and gray surfaces, Network method, Reradiating surfaces.Multimode heat transfer.Gaseous emission and absorption.Radiative exchange in furnaces,Radiation characteristics of particle systems, Thermal radiation of a luminous fuel oil and gas- Soot flame- overall heat transfer in furnaces.Radiation in gases and vapour. Gas radiation and radiation heat transfer in enclosures containing absorbing and emitting media – interaction of radiation with conduction and convection.	10
3	**Principle of Fluid flow and Convective heat transfer:** Concept of velocity and thermal boundary layers: Laminar and Turbulent flow. Navier-stokes equations and convection equation.Boundary layer approximations and special conditions.Boundary layer similarity. The normalized convection transfer equations. Dimensionless parameters & physical significance, Reynolds analogy, Chilton-Colburn analogy. Forced Convection (External Flow): Flat plate in parallel flow, the Blasiusssolution(highlights only), local and average Nusselt number calculations, mixed boundary layer considerations. Forced Convection (Internal Flow): Laminar flow in a pipe friction factor, thermal considerations, mean temperature, constant heat flux and constant wall temperature.Thermal analysis and convection correlations for laminar flow in circular tubes, Evaluation of Nusselt number, Marcos and Bergles correlation. Convection correlations for turbulent flow in circular tubes and non circular tubes. Heat transfer enhancement, Passive, active and compound techniques.	10
4	**Free Convection:**Physical considerations, governing equations, similarity considerations. Laminar free convection on a vertical surface, effects of turbulence. Empirical correlations for external free convection flows for various geometries and orientations.Free convection within parallel plate channels.Empirical correlations for enclosures.Mixed convection. Momentum and Energy Equations, Turbulent Boundary Layer Heat Transfer, Mixing length concept, Turbulence Model – K Є Model, Analogy between Heat and Momentum Transfer – Reynolds, Colburn, Prandtl Turbulent flow in a Tube, High speed flows.	10

5	**Boiling and Condensation**: Heat transfer with phase change – condensation and boiling heat transfer- Heat transfer in condensation, Effect of non-condensable gases in condensing equipment, Condensation with shear edge on bank of tubes, Boiling – pool and flow boiling, **Heat Exchanger**: Heat exchanger, Є – NTU approach and design procedure, compact heat exchangers.	10
6	**Mass Transfer**: Mass Transfer, Vaporization of droplets, combined heat and mass transfer, Heat Transfer Correlations in various applications like I.C. Engines, Compressors & turbines. **Numerical methods in heat transfer**: Finite difference formulation of steady and transient heat condition problems - Discretization schemes - Explicit, Crank Nicolson and Fully implicit schemes, Control volume formulation, Steady one dimensional convection problems, Calculation of the flow field – SIMPLER Algorithm.	10

References:

1. Incropera F.P. and DeWitt. D.P., Fundamentals of Heat & Mass Transfer, John Wiley & Sons, 1996.
2. Ozisik. M.N., Heat Transfer – Basic Approach, McGraw-Hill Co., 1985.
3. Schlichting, Gersten, Boundary layer Theory, Springer, 2000
4. P.K. Nag, Heat Transfer, Tata McGraw-Hill, 2002
5. Rohsenow. W.M., Harnett. J. P. and Ganic. E.N., Handbook of Heat Transfer Applications, McGraw-Hill, NY1985
6. Anthony F. Mills, Basic Heat and Mass Transfer, Irwin Publishers.
7. Kakac, S. and Yener, Y., Convective Heat Transfer, CRC Press, 1995.
8. Kraus, A.D., Aziz, A., and Welty, J., Extended Surface Heat Tran5fer, John Wiley, 2001.
9. Eckert. E.R.G. and Drake. R. M., Analysis of Heat and Mass Transfer, McGraw Hill Co., 1980.
10. Bejan. A., Convection Heat Transfer, John Wiley and Sons, 1984.
11. Patankar. S.V. Numerical heat Transfer and Fluid flow, Hemisphere Publishing Corporation, 1980.
12. Carnahan B., Luther H. A., and Wilkes, J.O., Applied Numerical Methods, Wiley and Sons, 1976.
13. Welty JR, Wicks CE, Wilson RE, Fundamental of momentum, heat and mass transfer, John Wiley and Sons, 1984

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Subject Code	Subject Name	Credits
HPC202	**Advanced Fluid Mechanics**	**04**

Module	Detailed content	Hours
1	**Governing Equations**: mass conservation in differential and integral forms, Reynolds's transport theorem, Fluid kinematics – Physical conservation laws, Flow kinematics, and Momentum equation: substantial derivative, differential and integral form, stress tensor, stress strain relations, Ideal Fluid flow concepts.	10
2	**Navier-Stokes Equations**: Special forms: Euler equations, Bernoulli equation, stream function, Vorticity. Exact solutions: fully developed flow in channel, pipe, flow between concentric rotating cylinders, Couette flow, Stokes First problem (unsteady flow), Creeping flow past a sphere, cylinder.	10
3	**Boundary Layers**: Boundary layer assumptions, equations, flow over a flat plate, similarity (Blasius) solution, Falkner-Skan equation, momentum integral method, external flows: drag, lift, flow separation.	08
4	**Turbulent flow:** Introduction to hydrodynamic stability, characteristics of turbulence, governing equations, turbulent boundary layer, algebraic models (Prandtl's mixing length), velocity profile over a flat plate and in pipes. **Turbulent Shear Flows:** Equations for free shear layers: mixing layer, plane and axisymmetric jet, wake. Turbulent energy equation, two equation model (k-epsilon), Large Eddy Simulation, Various Turbulent Models.	12
5	**Compressible Flow:** One-dimensional Flow: speed of sound, variable cross-section flow, converging diverging nozzle, effect of friction and heat transfer, normal shock relations, Introduction to oblique shocks, 2-dimensional flows(subsonic and supersonic) past slender bodies, compressible boundary layers.	10
6	**Shocks:** Normal and oblique shocks, Prandtl – Meyer expansion, Rankine – Hugnoit relation, Application of method of characteristics applied to two dimensional cases, simple supersonic wind tunnel, Design of supersonic wind tunnel and nozzle.	10

References:

1. Advanced Fluid Mechanics, G. Biswas and K. Muralidhar
2. White, P.M., Viscous Fluid Flow, 2nd ed., McGraw-Hill, 1991.
3. Boundary Layer Theory, H. Schlichting
4. Fluid Mechanics, Cengel, Tata McGraw Hill
5. Fluid Mechanics, F.M. White, McGraw Hill Int.
6. Currie, LG., Fundamental Mechanics of Fluids, 3rd ed., CRC Press, 2002.
7. Ockendon, H. and Ockendon, J., Viscous Flow, Cambridge Uni. Press, 1995.
8. Mohanty A K Fluid Mechanics, Prentice Hall of India, 1986
9. Shapiro A F The Dynamics of Compressible flow Vd 1, The Ronald Press Company 1963
10. Shames, Mechanics of Fluids, MC grow Hill 1962 Book Company 1962
11. Schlichting H Boundary layer theory MC Grow Hill Book company 1979
12. S M Yahya, Compressible Fluid Flow.

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Subject Code	Subject Name	Credits
HPC203	**Instrumentation & Control Systems**	**04**

Module	Detailed content	Hours
1	**Introduction:** Introduction to measurements for scientific and engineering application need and goal, Broad category of methods for measuring field and derived quantities.	08
2	**Instrument Classification**: Characteristics of Instruments – Static and dynamic, zero order, first order, second order instruments, experimental error analysis, Systematic and random errors, Statistical analysis, Uncertainty, Experimental planning and selection of measuring instruments Reliability of instruments, Review of basic measurement techniques. Data logging and acquisition, use of intelligent instrument for error reduction, elements of micro-computer interfacing, intelligent instruments in use, Error analysis - Uncertainty propagation – Oscilloscope for analysis of dynamic and transient events.	12
3	**Measurement of Physical Properties:** Measurement of field quantities, thermometry, heat flux measurement, measurement of force, pressure, flow rate, velocity, humidity, noise, vibration, measurement of the above by probe and non – instructive techniques, measurement of derived quantities, torque, power, measurement of thermo-physical properties, instruments for measuring temperature pressure and flow, use of intelligent instruments for the physical variables.	10
4	**Measurement of fluid Properties:** Chemical, thermal, magnetic and optical gas analyzers, measurement of smoke, dust and moisture, gas chromatography, spectrometry, measurement of pH, Techniques, shadow graph, Schlieren, interferometer, Laser Doppler anemometer, heat flux measurement, Telemetry in engines. Principles and analysis of measurement systems used for measurement of flow, power, pressure, and temperature.	10
5	**Basics of control system:** Types of control, proportional control, Derivative control, Integral control, PID control, Programmable logic controllers. pneumatic and hydraulic controllers, electronic controllers, applications to machine tools, furnaces, material handling etc	10
6	**Digital Transducers:** Interface system and Standards, Computer automated measurements and controls (CAMAC) standards, IEEE 488 standard interface, Remote monitoring and control of boiler houses, D-DAC (Distributed Data acquisition and Control Systems) – Microprocessor based temperature control system, Introduction to Microcontrollers, Process control system, Pneumatic control systems.	10

References:

1. Barney, Intelligent Instrumentation, Prentice Hall of India, 1988.
2. Prebrashensky. V., Measurement and Instrumentation in Heat Engineering, Vol.1 and 2 MIR Publishers, 1980.
3. Raman, C.S. Sharma, G.R., Mani, V.S.V., Instrumentation Devices and Systems, Tata McGraw-Hill, New Delhi, 1983.
4. Doeblin, Measurement System Application and Design, McGraw-Hill, 1978.
5. Morris. A.S, Principles of Measurements and Instrumentation Prentice Hall of India, 1998.
6. George C Barney, Intelligent Instrumentation Microprocessor and Applications in Measurements and Control, Prentice Hall, New Delhi, 1995.
7. Beckwith, T.G., Buck, L., and Marangoni, R.D., Mechanical Measurements, Narosa Pub. House, 1987.
8. Hewlett Packard, Practical Temperature Measurements - Application Note 290, 1995.
9. Liptak B.G. Instrument Engineers' Handbook
10. Bolton W, Mechatronics-Electronics Control Systems in Mechanical and ElectricalEngg.
11. A.D. HelfrickandW.D. Cooper, Modern Electronic Instrumentation and Measurement Technique.
12. Johnson C.D., Process Control Instrumentation.

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Subject Code	Subject Name	Credits
HPE2031	**Cryogenics**	**04**

Module	Detailed content	Hours
1	**Introduction to Cryogenic systems**: Present areas involving Cryogenic Engineering, Lowtemperature properties of materials- Mechanical properties, Thermal properties, Electricaland Magnetic Properties, Properties of Cryogenic Fluids, Properties of solids at cryogenic temperatures;Superconductivity.	08
2	**Liquefaction Systems**– Production of Low temperatures- Joule Thomson effect, adiabaticexpansion, Liquefaction systems for gasses other than neon, Hydrogen and Helium andfor hydrogen neon and helium, Comparison of Liquefaction systems, Critical componentsinvolved in Liquefaction systems.Carnot Liquefaction Cycle, F.O.M. and Yield of Liquefaction Cycles, Gas liquefaction systems: Recuperative – Linde – Hampson, Claude, Cascade,Heylandt, Kapitza, Collins, Simon; Regenerative – Stirling cycle and refrigerator,Slovay refrigerator, Gifford-McMahon refrigerator, Vuilleumier refrigerator, PulseTube refrigerator; Liquefaction of natural gas.	12
3	**Instrumentation, measurement systems** : Temperature, Pressure, Flow rate, Fluid quality,Liquid level measurement systems, Vacuum insulation, Evacuated porous insulation, Gas filled powders and fibrous materials, Solid foams, Multilayer insulation, Liquid and vapourShields, Cryogenic insulation, Composite insulations.	10
4	**Storage of cryogenic liquids:** Design considerations of storage vessel; Dewar vessels;Industrial storage vessels; Storage of cryogenic fluids in space; Transfer systems andLines for cryogenic liquids; Cryogenic valves in transfer lines; Two phase flow inTransfer system; Cool-down of storage and transfer systems.	10
5	**Cryogenic Refrigeration Systems:** Ideal Refrigeration systems - Joule ThomsonRefrigeration systems, Philips refrigerator, Solvay refrigerator, Mac Mohan Refrigerator,Regenerator. Refrigerators above 2K and below 2K. Magnetic cooling, Thermodynamicsof Magnetic cooling, Magnetic moment and Entropy of Paramagnetic materials, Magneticrefrigeration systems, thermal valves, Dilution refrigerators.	10
6	**Cryogenic equipment**: Cryogenic heat exchangers – recuperative and regenerative;Variables affecting heat exchanger and system performance; Cryogenic compressors,Pumps, expanders; Turbo alternators; Effect of component inefficiencies; SystemOptimization. **Applications:** Magneto-caloric refrigerator; ^{3}He-^{4}He Dilution refrigerator; Cryopumping; CryogenicEngineering applications in energy, aeronautics, space, industry, biology, preservationApplication of Cryogenic Engineering in Transport.	10

References:

1. Cryogenics: Applications and Progress, A. Bose and P. Sengupta, Tata McGraw Hill.
2. Cryogenic Engineering, T.M. Flynn, Marcel Dekker
3. Handbook of Cryogenic Engineering, Editor – J.G. Weisend II, Taylor and Francis
4. Cryogenic Systems, R. Barron, Oxford University Press.
5. Cryogenic Process Engineering, K.D. Timmerhaus and T.M. Flynn, Plenum Press.
6. Cryogenic Fundamentals, G.G. Haselden, Academic Press.
7. Advanced Cryogenics, Editor – C.A. Bailey, Plenum Press.
8. Applied Cryogenic Engineering, Editors – R.W. Vance and W.M. Duke, John Wiley& sons.

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Subject Code	Subject Name	Credits
HPE2032	**Modelling& Simulation of IC Engines**	**04**

Module	Detailed content	Hours
1	**Simulation principles-** First and second laws of thermodynamics – Estimation of properties of gas mixtures - Structure of engine models – Open and closed cycle models - Cycle studies, Chemical Reactions, First law application to combustion, Heat of combustion – Adiabatic flame temperature, Chemical Equilibrium and calculation of equilibrium composition - – Heat transfer in engines – Heat transfer models for engines.	10
2	**Simulation in S I engine**– Combustion in premixed flames, stages of combustion, flame propagation, rate of pressure rise, cycle-to-cycle variation, abnormal combustion - theories, effect of engine operating variables on combustion, Combustion in SI engines, Flame propagation and velocity, Single zone models – Multi zone models – Mass burning rate, Turbulence models – One dimensional models – Chemical kinetics modeling – Multidimensional models	10
3	**Simulation in C I engine:** Combustion in diffusion flames - droplet and spray combustion theory, stages of combustion, delay period, peak pressure, heat release, gas temperature, diesel knock, Combustion in CI engines Single zone models – Premixed-Diffusive models – Wiebe' model – Whitehouse way model, Two zone models - Multizone models- Meguerdichian and Watson's model, Hiroyasu's model, Lyn's model – Introduction to Multidimensional and spray modelling	10
4	**Thermodynamics of the gas exchange process**– Flows in engine manifolds – One dimensional and multidimensional models, Flow around valves and through ports Models for scavenging in two stroke engines – Isothermal and non-isothermal models	08
5	**Modelling of ICEngines:** Heat of reaction - Hrp&Urp calculations, adiabatic, constant volume combustion, constant pressure combustion, temperature drop due to fuel vaporization, adiabatic flame temperature, mean effective pressure, torque and thermal efficiency at full throttle, part throttle and supercharged conditions. Spray models, flow models and combustionmodels	10
6	**Simulation of IC Engines:** SI & CI engine simulation – air standard cycle, fuel-air cycle, progressive combustion cycle and actual cycle simulation – part throttle, full throttle and supercharged conditions Mathematical modelling of Catalytic converters, one dimensional model- 2D axisymmetric model of monolithic reactor, Computation of chemical reactions, two dimensional transient temperature field. **Simulation of New Engine Concepts:** Dual fuel engine, low heat rejection engine, lean burn engine, variable compression ratio engine, homogeneously charged compression ignition engine, controlled auto ignition engine.	12

References:

1. Ashley S. Campbell, Thermodynamic Analysis of Combustion Engines, John Wiley and Sons, 1980.
2. V.Ganesan, Computer Simulation of Spark Ignition Engine Processes, Universities Press, 1995.
3. V.Ganesan, Computer Simulation of Compression Ignition Engine Processes, Universities Press, 2002.
4. Gordon P. Blair, The Basic Design of two-Stroke engines, SAE Publications, 1990.
5. Horlock and Winterbone, The Thermodynamics and Gas Dynamics of Internal Combustion Engines, Vol. I & II, Clarendon Press, 1986.
6. J.I.Ramos, Internal Combustion Engine Modelling, Hemisphere Publishing Corporation, 1989.
7. J. N. Mattavi and C. A. Amann, Combustion Modelling in Reciprocating Engines, Plenum Press, 1980.

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Subject Code	Subject Name	Credits
HPE2033	**Cogeneration and Waste Heat Recovery Systems**	**04**

Module	Detailed content	Hours
1	**Introduction:** Introduction - Principles of Thermodynamics, Cycles-Topping and Bottoming, combined cycle, Organic Rankine Cycles, Performance indices of cogeneration systems, waste heat recovery, sources and types, Concept of tri-generation.	10
2	**Cogeneration Technologies:** Configuration and thermodynamic performance, steam turbine cogeneration systems, gas turbine cogeneration systems, reciprocating IC engines cogeneration systems, combined cycles cogeneration systems, Advanced cogeneration systems: fuel cell, Stirling Engines	10
3	**Issues and Applications of Cogeneration Technologies:** Cogeneration plants electrical interconnection issues, Utility and cogeneration plant interconnection issues, Applications of Cogeneration in utility sector, Industrial sector, building sector, rural sector, Impacts of cogeneration plants, fuel, electricity and environment	10
4	**Waste Heat Recovery Systems:** Selection criteria for waste heat recovery technologies, Recuperators, Regenerators, Plate Heat Exchangers, thermic fluid heaters, Waste Heat Boilers, classification, Location, Service Conditions, Design Considerations , heat pipe exchangers , heat pumps – absorption systems.	10
5	**Economic Analysis:** Economic analysis for cogeneration and waste heat recovery systems, Investment cost, economic concepts, measures of economic performance, procedure for economic analysis.	10
6	**Optimization**: Procedure for optimized system selection and design, load curves , sensitivity analysis, regulatory and financial frame work for cogeneration and waste heat recovery systems	10

References:

1. EDUCOGEN – The European Educational tool for cogeneration, Second Edition, 2001
2. Horlock JH, Cogeneration Heat and Power, Thermodynamics and Economics, Oxford,1987
3. Charles H.Butler, Cogeneration, McGraw Hill Book Co., 1984.
4. Institute of Fuel, London, Waste Heat Recovery, Chapman & Hall Publishers, London, 1963.
5. SenguptaSubrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.
6. De NeversNoel., Air Pollution Control Engineering, McGraw Hill, New York,1995.

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Subject Code	Subject Name	Credits
HPE2041	**Design & Performance of Heat Exchanger**	**04**

Module	Detailed content	Hours
1	**Basic design methods for heat exchanger**- Design of shell and tube type heat exchanger, Regenerators and Recuperators - TEMA code.	10
2	**Plate heat exchanger**, Compact heat exchanger, spiral plate heat exchanger, plate heat exchanger for Dairy industry, Codes of mechanical design of heat exchanger,Selection of compact heat exchangers. **Computerized methods** for design and analysis of heat exchanger.	10
3	**Performance enhancement of heat exchanger:** Fouling of heat exchanger. Heat Transfer and Pressure Loss - Flow Configuration - Effect of Baffles – Effect of Deviations from Ideality -Design of Typical Liquid - Gas-Gas-Liquid Heat Exchangers Testing, evaluation and maintenance of heat exchanger.	12
4	**Power plant heat exchanger**: Heat exchanger for heat recovery at low, medium and high temperatures. Regenerators, Principles of boiler design, recuperators, matrix heat exchanger and heat pipe exchanger.	10
5	**Thermal design of heat exchange equipments:** Air pre-heaters, Economizer – Super heater and condensers, Furnaces, Radiative heat exchangers.	10
6	**Recent developments in heat exchangers:** Industrial applications	08

References:

1. Heat Transfer by F. Incropera and D. DeWitt or other basic undergraduate heat transfer textbook.
2. Compact Heat Exchangers by W. Kays and A. London, National Press.
3. Compact Heat Exchangers by R. Shah, A. Kraus, D. Metzger, Hemsisphere Publishing Corporation.
4. Heat Exchanger Design byFraas, Arthur P. Fraas, M NecatiÖzisik, Wiley-IEEE.
5. Heat exchanger, Design, rating and Selection, SadikKakac, CRC Press
6. Heat Exchangers Thermal Hydraulic Fundamentals and Design by S. Kakac, A.,Bergles, F. Mayinger, McGraw-Hill Book Company.
7. Automotive Heating and Air Conditioning by Tom Birch, Prentice Hall
8. T. Taborek, G.F. Hewitt and N.Afgan, Heat Exchangers, Theory and Practice, McGrawHill Book Co., 1980
9. Walker, Industrial Heat Exchangers - A Basic Guide, McGraw Hill Book Co., 1980.
10. Ganapathy, V., *Applied Heat Transfer,* Pennwell Books, 1982.

Assessment:

Internal: Assessment consists of two tests out of which; one shouldbe compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students.Minimum 80%syllabus should be covered in question papers of endsemester examination.

Subject Code	Subject Name	Credits
HPE2042	**Computational Heat Transfer**	**04**

Module	Detailed content	Hours
1	**Introduction:** Weighted Residual Methods, Shape functions, Coordinate systems, Numerical Integration. Modeling of Heat Conduction, Variational Formulation, Galerkin's Approach for one dimensional and two dimensional problems Introduction – A one dimensional Problem solved using a single element – Linear element, Quadratic element, the use of numerical integration. A one dimensional problem solved using an assembly of elements.	10
2	**Time stepping methods for Heat Transfer:**Galerkin's approach in Non-linear transient heat conduction problems. **Upwind Finite Elements in One Dimension:** Heat Transfer in fluid flow between parallel planes, Convection on melting and solidification.	08
3	**Classification of Partial Differential Equations (PDE):**Introduction to Finite Difference, Finite Volume and Integral Methods. Solution of Steady and Transient Heat Conduction Problems, Solution of Laplace and Poission type PDEs, Introduction of Explicit and Implicit Schemes, Stability and Consistency of Numerical Methods, Fourier Stability Analysis of typical Solution Algorithms. Alternate Direction Implicit (ADI) method.	12
4	**Solution of Simultaneous Algebraic Equations**: Tri-Diagonal-Matrix Algorithm (Thomas Algorithm), Gauss-Siedel and Gauss-Jordon Methods, Strongly Implicit Procedures (SIP Solvers – Stone's Algorithm) for two and three dimensional problems.	10
5	**Introduction to VorticityTransport Equation:** Vorticity Transport Equation in Two Dimensions, Solution of Fluid Flow Problems by Stream-function Vorticity Method.Examples of Derived Boundary Conditions for Stream Function and Vorticity.Derivation of Pressure Poission Equation and Their Solution.	10
6	**Solution of Transport Equations** Integration of Navier Stokes equation in primitive variables and Scalar Transport Equation. Various Schemes of Discretization – First and Second Order Upwind Schemes, QUICK, Hybrid, Exact and Exponential Differencing Schemes.	10

References:

1. H. R. Thomas, K. N. Seetharamu, Ken Morgan, R. W. Lewis, "The Finite Element Method in Heat Transfer Analysis", John Wiley & Sons Inc, 1996.
2. Roland W. Lewis, PerumalNithiarasu and K.N. Seetharamu, "Fundamentals of the FiniteElement Method for Heat and Fluid Flow", Wiley; 1 edition, 2004.
3. J.N. Reddy and D.K. Gartling, "The Finite Element Method in Heat Transfer and Fluid Dynamics", CRC; 2 edition, 2000.

Assessment:

Internal: Assessment consists of two tests out of which; one shouldbe compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students.Minimum 80%syllabus should be covered in question papers of endsemester examination.

Subject Code	Subject Name	Credits
HPE2043	**Non-Conventional Power Plants**	**04**

Module	Detailed content	Hours
1	**Introduction**: Potential of renewable energy sources, renewable electricity and key elements, Global climate change, CO_2 reduction potential of renewable energy.	10
2	**Solar energy:** Solar thermal power plants (Concentrators, solar chimney etc.), Solar thermal conversion devices, Economics and social considerations, Design considerations of component selection. Solar photovoltaic power plants, photovoltaic technology, Design of a photovoltaic system, economics and costing, Application as a distributed power supply strategy.	12
3	**Wind energy:** Wind energy potential measurement, wind electric generator component design, economics and demand side management, energy wheeling, and energy banking concepts.	10
4	**Biogas:** properties of biogas (Calorific value and composition), biogas plant technology and status.	08
5	**Other plants:** Fuel cell based power plants, tidal and wave energy plant design, OTEC power plants.	08
6	**Geothermal energy:** hot springs and steam ejection site selection, power plants, and economics. **Environmental considerations:** Environmental impacts, Economic and social considerations, financing mechanisms, Carbon credits, Clean development mechanisms.	12

References:

1. S.P.Sukhatme, Solar Energy – Principles of thermal collection and storage, II edition,Tata McGraw Hill, New Delhi, 1996.
2. J.A.Duffie and W.A.Beckman, Solar engineering of Thermal processes, II edition,John Wiley, New York, 1991.
3. D.Y.Go swami, F.Keith and J.F.Krieger, Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000.
4. D.D.Hall and R.P.Grover, Biomass Regenerable Energy, John Wiley, New York,1987.

Assessment:

Internal: Assessment consists of two tests out of which; one shouldbe compulsory class test (on minimum 02 Modules) and the other is either a class test or assignment on live problems or course project.

End Semester Examination: Some guidelines for setting the question papers are as, six questions to be set each of 20 marks, out of these any four questions to be attempted by students.Minimum 80%syllabus should be covered in question papers of endsemester examination.

Subject Code	Subject Name	Credits
HPL203	**Modelling& Simulation of IC Engines**	**01**

Module	**Detailed content**	**Lab Sessions**
1	**Performance of four stroke engines** • Performance trial on 4-cylinder 4-stroke petrol engine • Performance trial on diesel engine • Emission measurements by using gas analyzer and smoke meter	04
2	**Simulation of IC Engines:** • Simulation of SI Engine • Simulation of CI Engine • Simulation of new developments in Fuel Cell using CFD.	05
3	**Design and actual application of IC engines:** • Design, manufacture and testing of Composite usage for Bumper, Crankshaft, Propeller Shaft and Valves. • Aerodynamic Simulation of a road vehicle using CFD. • Case study for engine selection • Visit to research organization	06

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
HPL204	**Computational Heat Transfer and Fluid Flow**	**01**

Module	Detailed content	Lab Sessions
1	**Simulation of basic problems of Heat Transfer** • Basic problems in Heat Transfer Analysis using ANSYS / NASTRAN • 1D, 2D and 3D conduction field problems • Convection problems • Heat Transfer in Fluid Flow	05
2	**Numerical Simulation of modes of Heat Transfer** • Numerical method in heat conduction & convection. • Passive heat transfer augmentation techniques. • One problem on network method (Radiation).	04
3	**Simulation of Fluid Flow and Nozzles** • Flow over a cylinder/sphere at different Re. Pressure variation over the body and drag estimation • Flow past an aerofoil: Pressure measurements, calculation of lift • Flow through a converging-diverging nozzle: subsonic and supersonic flows Friction factor Determination: incompressible flow through pipes/ducts of variable cross-section Laminar/Turbulent boundary layer over a flat plate. • Numerical simulation of flow through a c-d nozzle.	06

Assessment:

End Semester Examination: Practical/Oral examination is to be conducted by pair of internal and external examiners

Subject Code	Subject Name	Credits
HPS301	**Seminar**	**03**

Guidelines for Seminar

- Seminar should be based on thrust areas in Mechanical Engineering.
- Students should do literature survey and identify the topic of seminar and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the topic and compile the report in standard format and present in front of Panel of Examiners.(pair of Internal and External examiners appointed by the University of Mumbai)
- **Seminar should be assessed based on following points**
  - Quality of Literature survey and Novelty in the topic
  - Relevance to the specialization
  - Understanding of the topic
  - Quality of Written and Oral Presentation

NOTE :

1. Assessment of Seminar will be carried out by a pair of Internal and External examiner. The external examiner should be selected from approved panel of examiners for Seminar by University of Mumbai, OR faculty from Premier Educational Institutions /Research Organizations such as IIT, NIT, BARC, TIFR, DRDO, etc. OR a person having minimum Post-Graduate qualification with at least five years experience in Industries.

2. Literature survey in case of seminar is based on the broader area of interest in recent developments and for dissertation it should be focused mainly on identified problem.

3. At least 4-5 hours of course on Research Methodology should be conducted which includes literature survey, identification of problems, analysis and interpretation of results and technical paper writing in the beginning of 3rd semester.

Subject Code	Subject Name	Credits
HPD301 / HPD401	**Dissertation (I and II)**	**12 + 15**

Guidelines for Dissertation

- Students should do literature survey and identify the problem for Dissertation and finalize in consultation with Guide/Supervisor. Students should use multiple literatures and understand the problem. Students should attempt solution to the problem by analytical/simulation/experimental methods. The solution to be validated with proper justification and compile the report in standard format.

Guidelines for Assessment of Dissertation I

- Dissertation I should be assessed based on following points
  - Quality of Literature survey and Novelty in the problem
  - Clarity of Problemdefinition and Feasibility of problem solution
  - Relevance to the specialization
  - Clarity of objective and scope
- Dissertation I should be assessed through a presentation by a panel of internal examiners appointed by the Head of the Department/Institute of respective Programs.

Guidelines for Assessment of Dissertation II

- Dissertation II should be assessed based on following points
  - Quality of Literature survey and Novelty in the problem
  - Clarity of Problemdefinition and Feasibility of problem solution
  - Relevance to the specialization or current Research / Industrial trends
  - Clarity of objective and scope
  - Quality of work attempted
  - Validation of results
  - Quality of Written and Oral Presentation
- On completion of data collection, analysis, and validation the student shall prepare an interim report and shall present a seminar on the work done, before the submission of Synopsis to the University.
- Dissertation II should be assessed through a presentation jointly by Internal and External Examiners appointed by the University of Mumbai.
- Students should publish at least one paper based on the work in reputed International / National Conference (desirably in Journal).