FACULTY OF ENGINEERING

Syllabus for the

M.E. (Mechanical – Heat Power Engineering)

(w.e.f. 2008-2009)

UNIVERSITY OF PUNE

THE SYLLABUS IS PREPARED BY:

BOS-Mechanical Engineering
University of Pune

PEER REVIEW BY:

- **Mr. M.S. Ranade, Thermax**
- **Mr. Arvind Surange, AER Project Consultant**
- **Prof. M.R. Khadilkar**
- **Prof. Dr. M. S. Loknath**
- **Prof. Dr. N. K. Sane**

Note: This Syllabus is subjected to change without prior notice by the concerned BOS

Minutes of Meeting

Minutes of Meetings of the Peer View Committee on M. E. (Mechanical) in Design Engineering, Mechatronics and Heat Power Engineering courses held at Sinhgad College of Engineering, Pune and PVG College of Engineering dated 19th April 2007, 6th October 2007 and 10th January 2008

A separate peer view committees for these above courses were formed and long discussion on the syllabus framing was take place. Following points were discussed and following resolutions were resolved.

1. Mathematics and Management subjects are included for all courses as suggested by Dean Faculty Engineering and Academic Council.
2. Credit system and audit course concepts are incorporated.
3. Topics on Elastic behaviour of anisotropic material and introduction to fracture mechanics are added while plastic bending is being deleted from subject Advanced stress analysis.
4. Topics on 'Multi degree freedom system, transfer matrix method, impulse response' are included and 'Dunkerley's method, Stodola's method' are deleted in subject Vibration and Noise Control.
5. Cam shaft design with valve opening mechanisms, piston, and connecting rod are added in Advanced Machine Design.
6. Project evaluation should be carried out on following points.
    1. selection of Project
    2. Selection of components
    3. costing
    4. specification developments
    5. testing and verification
7. First should have general seminar and second & third seminar should be on project topic and evaluated as term work.
8. Industrial visits should be incorporated in Lab Practices.
9. Dissertation should not be accepted for evaluation until all theory subjects were cleared by the concerned candidate.
10. Topic on 'Onsager equation, energy analysis of thermal systems' is added in Advanced Thermodynamics.
11. 50 to 60% marks are kept for quantitative questions.

Date: 4th April 2008 — Coordinator

Place : Pune — M. E. Syllabus Coordination committee

Program Structure for
M.E. Mechanical (Heat Power Engineering)
(For 2008 Course) (w.e.f. June – 2008)

Subject Code	Subject	Teaching Scheme		Examination Scheme				Credits
		Lect.	Pract.	Paper	TW	Or	Total	
Sem – I								
502101	Numerical Methods in Thermal and Fluid Engineering	03	-	100	-	-	100	03
502102	Advanced Thermodynamics	03	-	100	-	-	100	03
502103	Technology and Financial Management	03	-	100	-	-	100	03
502104	Elective – I	03	-	100	-	-	100	03
502105	Elective – II	03	-	100	-	-	100	03
502106	Lab. Practice – I	-	06	-	50	-	50	03
502107	Seminar- I	-	04	-	50	-	50	02
	Total	15	10	500	100	-	600	20
Sem – II								
502108	Advanced Heat Transfer	03	-	100	-	-	100	03
502109	Measurement Techniques and Data Analysis	03	-	100	-	-	100	03
502110	Advanced Fluid Mechanics	03	-	100	-	-	100	03
502111	Elective – III	03	-	100	-	-	100	03
502112	Elective – IV	03	-	100	-	-	100	03
502113	Lab. Practice – II	-	06	-	50	-	50	03
502114	Seminar – II	-	04	-	50	-	50	02
	Total	15	10	500	100	-	600	20

Sem – III

Subject Code	Subject	Teaching Scheme		Examination Scheme				Credits
		Lect.	Pract.	Paper	TW	Or	Total	
602115	Seminar – III	-	04	-	50	-	50	02
602116	Project Stage – 1	-	18	-	50	-	50	06
	Total	-	22	-	100	-	100	08

Sem- IV

Subject Code	Subject	Teaching Scheme		Examination Scheme				Credits
		Lect.	Pract.	Paper	TW	Or	Total	
602117	Project Stage – II	-	18	-	150*	50	200	12
	Total		18	-	150	50	200	12
	Grand Total						1500	60

*The term work of project stage II of semester IV should be assessed jointly by the pair of internal and external examiners, along with oral examination of the same.

Note- The Contact Hours for the calculation of load of teacher
Seminar- 1 Hr/week/student &
Project - 2 Hr / week / student

CODE	Elective – I	CODE	Elective – II
502104 A	Performance Assessment of Mechanical Equipments	502105A	Internal Combustion Engines
502104 B	Refrigeration Technology	502105 B	Advanced Air conditioning and Heating and Ventilation
502104 C	Energy Conservation and management	502105C	Conventional Power Plants
502104 D	Convective Heat Transfer Analysis	502105 D	Advanced Gas Dynamics

CODE	Elective – III	CODE	Elective – IV
502111 A	Internal Combustion Engines – fuels	502112 A	Heat Exchanger System Design and Performance
502111 B	Cryogenic Engineering	502112 B	Computational Fluid Dynamics
502111 C	Non Conventional Power Plants	502112 C	OPEN (SELF STUDY)**

**** Open elective subjects- BOS Mechanical Engineering will declare the list of subjects which can be taken under open elective.**

Numerical Methods in Thermal and Fluid Engineering (502101)

Teaching Scheme:
Lecture: 3 hrs/week

Examination
Paper: 100 Marks
Paper Duration: 3 hrs.

1. Linear Algebraic Equations:- Gauss – Elimination, Gauss – Seidel, LU Decomposition.
2. Roots of equations: - Bisection Method, False position method, Newton – Raphson Method, Muller's method, Bairstow's Method.
3. Curve fitting – Least square regression:-
   i) Linear regression, multiple linear regressions, polynomial regression.
   ii) Non linear regression – Gauss – Newton method, multiple non linear regression.
4. Interpolation: - Newton's Divided Difference, Lagrange's Inverse, Spline, Hermite Interpolation, Extrapolation technique of Richardson's Gaunt.
5. Differentiation & Integration:- Divided difference formulae, Romberg integration, Gauss quadrature for double & triple integration.
6. Eigen Values & Eigen Vectors of Matrices – Faddeev- Laeverrier's method, Power Method, Householder & Given's method.
7. 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.
8. 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.

* Numerical methods should have orientation in thermal and fluid engineering

Laboratory Practice – Solve eight assignments based on each of the above mentioned unit with programming.

References:-

1. Numerical Methods for Engineers, Steven C Chapra & Raymond P Canale, TMH, Fifth Edition
2. Applied Numerical Methods, Alkis Constantinides, McGraw Hill
3. Numerical Solution of Differential Equations, M.K. Jain, 2nd Edition, Wiley Eastern.
4. Numerical methods for scientific and engineering computation, Jain, Iyangar, Jain, New Age International Publishers.
5. Numerical methods in Engineering and Science, Dr. B.S. Garewal, Khanna Publishers.

Advanced Thermodynamics
(502102)

Teaching Scheme:
Lecture: 3 hrs/week

Examination
Paper: 100 Marks
Paper Duration: 3 hrs.

1. Equation of State
   State postulate for Simple System and equation of state, Ideal gas equation, Deviation from ideal gas, Equation of state for real gases, generalized Compressibility chart, Law of corresponding states
2. Properties of Pure Substances
   Phase change process of pure substances, PVT surface, P-v &P- T diagrams, Use of steam tables and charts in common use
3. Laws of thermodynamics, 2^{nd} law Analysis for Engg. Systems, Entropy flow & entropy generation, Increase of entropy principle, entropy change of pure sub, T-ds relations, entropy generation, thermo electricity, Onsager equation. Exergy analysis of thermal systems, decrease of Exergy principle and Exergy destruction
4. Thermodynamic Property Relations
   Partial Differentials, Maxwell relations, Clapeyron equation, general relations for du, dh, ds, and Cv and Cp, Joule Thomson Coefficient, Δh, Δu, Δs of real gases.
5. Chemical Thermodynamics
   Chemical reaction - Fuels and combustion, Enthalpy of formation and enthalpy of combustion, First law analysis of reacting systems, adiabatic flame temperature
   Chemical and Phase equilibrium - Criterion for chemical equilibrium, equilibrium constant 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 heat theorem and heat death of universe
6. Gas Mixtures – Mass & mole fractions, Dalton's law of partial pressure, Amagat's law, Kay's rule.
7. Statistical Thermodynamics- Fundamentals, equilibrium distribution, Significance of Lagrangian multipliers, Partition function for Canonical Ensemble, partition function for an ideal monatomic gas, equipartition of energy, Bose Einstein statistics, Fermi-Dirac statistics,

Exercises/ Assignments for laboratory Practice:

1. Computer aided energy analysis of steady flow cyclic system.
2. Study of mixture of gases, gas and vapour, estimation of properties and preparation of charts.
3. Analysis of ideal gas system using statistical thermodynamic techniques.
4. Study of behavior of pure substance with change in pressure and temperature.
5. Preparation of computer program to study the effect of percentage of theoretical on adiabatic flame temperature and equilibrium composition for a hydrocarbon fuel. (Program to be run for variable input data.)

Reference Books:

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 Stastistical 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.

Technology and Financial Management
(502103)

Teaching Scheme:
Lecture: 3 hrs/week

Examination
Paper: 100 Marks
Paper Duration: 3 hrs.

Finance:

-Functions
-Source of finance
-National & International finance
-Benefits & Limitations
-Budgets & Budgeting Control

Costing:

-Significance of engineers
-Traditional absorption costing
-Marginal costing
-Contract costing
-Activity based costing
-Process costing

Engineering Economic Analysis:

-Basic concepts & price theory
-Supply & Demand
-Consumer behaviour
-Law of reducing returns
-Competition- types, equilibrium
-Inflation & unemployment
-Foreign trade
-Balance of payment

Quality Management:

-Fundamentals of TQM, Deming, Juran
-Kaizen
-JIT
-ISO 9000
-ISO 14000

Project Management:

-**Project life cycle**
-CPM
-PERT
-BOT
-Public Private Participation

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

Books:

1) S C Kuchal, Indian Economics
2) Prasad N K, Cost Accounting, Book Syndicate Pvt. Ltd., Kolkata 700 009
3) Collin Drury, Management & Cost Accounting, English Language Book Series, Chapman & Hall, London [ISBN 0412 341204]
4) E Dessler, Human Resource Management
5) R S Dwivedi, Managing Human Resporces
6) Chase Operations Management for Competitive Advantage
7) B S Sahay, World Class Manufacturing
8) Juran, Quality Control Handbook
9) K Ishikawa, Guide to Quality Control
10) Fred Luthans, McGraw Hill Publications, Organizational Behaviour
11) Robbins S P, Prentice Hall Publications, Organizational Behaviour

Performance Assessment of Mechanical Equipments

Elective-I (502104-A)

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
Paper: 100 Marks
Paper Duration: 3 hrs.

1. Boilers
Introduction, types, combustion in boilers, performances evaluation, analysis of losses, feed water treatment, blow down, energy conservation opportunities.

2. Boiler Performance
Performance terms and definitions, reference standards, direct and indirect method testing, boiler efficiency calculation, factors affecting boiler performance, modern trends.

3. Furnaces
Classification, types of fuels, general fuel economy measures in furnaces, excess air, heat distribution, temperature control, draft control, waste heat recovery, performance terms and definitions, furnace efficiency, testing method.

4. Cogeneration
Definition, need, application, advantages, classification, energy saving, performance terms and definitions, field testing procedure, diesel generating system-factors affecting selection, energy performance assessment of diesel conservation avenues, trends in different cogeneration power plants.

5. Fans and Blowers
Types, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities, performance terms and definitions, field testing

6. Pumps and Pumping System:
Types, pumping system components, performance evaluation, efficient system operation, flow control strategies and energy conservation opportunities, performance terms and definitions, field testing

7. Compressed Air System:
Types of air compressors, compressor efficiency, efficient compressor operation, Compressed air system components, capacity assessment, and leakage test, factors affecting the performance and savings opportunities.

8. Energy Conservation:
Energy conservation in, boilers, furnaces, pumps, fans, pumping systems, compressed air systems, Waste heat recovery: recuperators, heat wheels, heat pipes, heat pumps.

Exercises/ Assignments for laboratory Practice:

List of Experiments (Any Four)
1. Performance evaluation of Boiler by Direct and Indirect Method.
2. Performance evaluation of Furnace.
3. Energy audit of a Cogeneration system.
4. Performance analysis of Diesel Generating Set.
5. Performance Test Report on Cooling Air Fan.
6. Field Testing for Determination of Pump Efficiency.
7. Performance assessment of Compressed Air System.

Reference Books:

1. Energy Performance assessment for equipment and Utility Systems.-Vol. 2,3.4 BEE Govt. Of India.
2. Handbook on Energy Audit and Environment Management, Abbi Y.A, Jain, Shashank TERI Press New Delhi,2006
3. Energy Management Handbook, Wayne C Turner, The Fairmont Press Inc.
4. Boiler Operator's Guide Fourth Edition, Anthony L Kohan, McGraw Hill.
5. Boiler Test Calculations – J. Senior, Edward Arnold Publisher.
6. Gas Turbine Engineering Handbook, Meherwan P Boyce, Gulf Publishing Company.
7. Modeling of Gas Fired Furnaces & Boilers, Rhine J M
8. Pumps, Principles and Practice, Jaico Publishing House, Mumbai.
9. Reciprocating Compressors Operation and Maintenance, Heinz P Bloch & John J Hoefner, Gulf Publishing Company.
10. Fan Handbook, Frank P Bleier, McGraw Hill.
11. Principles and Performance in Diesel Engineering, Sam Haddad and Neil Watson, Elliss Harward Series Engineering Science.

Refrigeration Technology
Elective-I (502104-B)

Teaching Scheme:
Lecture: 3 hrs/week

Examination
Paper: 100 Marks
Paper Duration: 3 hrs.

1. 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
2. Refrigerant: Designation, selection, desirable properties, refrigerant blends, secondary refrigerants, refrigerant recycling, reclaim and charging, alternative refrigerants, refrigerant-lubricant mixture behavior, ODP, GWP concepts
3. 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
4. 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.
5. Compressor rating and selection- reciprocating, screw, Scroll and centrifugal compressors based on applications
6. Evaporators: types, thermal design, effect of lubricants accumulation, draining of lubricants, selection and capacity control
7. Condenser: types, thermal design, purging, selection and capacity control
8. Selection of expansion devices, Design of refrigerant piping refrigeration system controls and safety devices, Solenoid valves, suction and evaporator pressure regulators, Thermal Insulation
9. Motor selection: Single phase, Three phase, Starters, Constant speed and Variable speed drive
10. Associated devices: high pressure receiver thermal design of low pressure receiver, accumulator, Filters, driers, oil separators, relief valves, safety valves, high and low pressure cut out, thermostats, water regulators etc.
11. 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.

(* Question Paper- 50% to 60% of maximum marks are kept for the questions asked on System Design and not any theory.)

Term Work

1. Trial on VCC as Heat pump
2. Trial on VCC- Effect of condensing and evaporator temperature on Performance
3. Visit report on (Any Two)
    (a) Cold Storage
    (b) Ice Plant
    (c) Dairy
    (d) Pharmaceutical
4. Design of Vapor Absorption System 100 kW or 200 kW or 300 kW etc.

Recommended Books

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. John A. Corinchock, Technician's guide to Refrigeration systems, McGraw-Hill
9. P.C. Koelet, Industrial Refrigeration: Principles, design and applications, Mcmillan
10. ASHRAE Handbook (i) Fundamentals (ii) Refrigeration
11. ISHRAE handbooks
12. ARI Standards
13. Refrigeration Handbook, Wang, Mc Graw Hill, Int.

ENERGY CONSERVATION AND MANAGEMENT
Elective I (502104-C)

Teaching Scheme: **Examination**
Lecture: 3 hrs/week **Paper: 100 Marks**
Paper Duration: 3 hrs.

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.

Energy economics – discount rate, payback period, and internal rate of return, life cycle costing.

Steam Systems : Boiler-efficiency testing, excess air control, steam distribution and use of steam traps, condensate recovery, flash steam utilisation, thermal insulation.

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.

Energy conservation in pumps, furnaces, fans, compressed air systems, refrigeration and air-conditioning systems. Waste heat recovery: recuperators, heat wheels, heat pipes, heat pumps.

Cogeneration: Concept options (steam / gas / turbine / diesel engine bases), selection criteria, control strategy.

TERM WORK

1) Application of energy conservation technique to one equipment such as air-compressor, air conditioning systems, furnace, etc.

2) Report based on industrial visit for study of energy audits, energy conservation methods.

3) Design of waste heat recovery system.

Convective Heat Transfer Analysis
Elective I (502104-D)

Teaching Scheme:
Lecture: 3 hrs/week

Examination
Paper: 100 Marks
Paper Duration: 3 hrs.

1. **Introduction**

2. **The Equations of Convective Heat Transfer**

3. **Some Solutions for External Laminar Forced Convection**
   Exact and Numerical Solutions.

4. **Internal Laminar Flows**
   Fully developed and thermally developing flows.

5. **Introduction to Turbulent Flows**
   Various models and Governing Equations.

6. **External Turbulent Flows**

7. **Internal Turbulent Flows**

8. **Natural Convection**
   Similarity solutions and Numerical solutions for Natural Convective Boundary Layer Equations.

9. **Combined Convection**

10. **Convective Heat Transfer through Porous Media.**

11. **Condensation**

Recommended Books:

Patrick H. Oosthuizen, David Naylor, "Convective Heat Transfer Analysis", Mcgraw Hill. Inc.[1999]

W. M. Kays, M. E. Crawford," Convective Heat and Mass Transfer", Mcgraw Hill. Inc. Third Edition [1993]

REFERENCES

1) L.C. Witte, P.S. Schmidt, and D.R. Brown: Industrial Energy Management and Utilisation, Hemispherical Publication, 1988.

2) T.L. Boyen: Thermal Energy Recovery: Wiley, 1980

3) Energy Management Handbook: Ed. W.C. Turner, Wiley, New York, 1982.

4) The Efficient Use of Energy: Ed. I.G.C. Dryden, Butterworth, and London, 1982.

5) Industrial Energy Conservation Manuals, MIT Press Mass. USA 1982

6) Technology Menu for Efficient Energy Use – Motor Drive Systems – National Productivity Council & Center for Environmental studies, Princeston University, USA, 1993

7) Handbook of Energy Conscious Buildings, IIT Bombay (MNES) , J K Nayak, 2006

8) Energy Conservation Book, TERI Publication

9) Energy Management, W.R.Murphy, Butterworth Heinemann.

(* Question Paper- 50% to 60% of marks are kept for the quantitative questions)

Internal Combustion Engines
Elective-II (502105-A)

Teaching Scheme: **Examination Scheme:**
Lectures: 3 hrs/week **Paper: 100 Marks**
Paper Duration: 3 hrs.

1)Measurement & Testing: Introduction ,engine performance parameters, measurement and testing, engine operating characteristics, performance maps

2)Engine Materials: Various engine components, cylinder head, spark plug, gaskets, cylinder block, piston ,piston rings, gudgeon pin ,connecting rod, crankshaft, bearings , crankcase ,fuel injector

3)Engine Design: Preliminary analysis, cylinder number, size and arrangement, experimental development

4)Electronic Injection System: Gasoline injection, EFI system, MPFI system , electronic control system ,injection timing, electronic diesel injection system and control

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, crankcase blow by

6)Simulation Technique: Application of simulation technique for engine tuning, engine selection parameters, recent trends in IC engines

Experiments (Any Three)

1. Performance trial on 4-cylinder 4-stroke petrol engine
2. Performance trial on diesel engine
3. Emission measurements by using gas analyzer and smoke meter
4. Case study for engine selection
5. Visit to research organization

References

1. The Internal Combustion Engine in Theory and Practice Volume I & II by Charles Fayette Taylor, The MIT Press
2. Internal Combustion Engines- V Ganesan, 2nd edition, TaTa McGraw Hill
3. Automotive Technology, Jack Erjavec,3rd edition, Delmar Thomson Learning
4. Design and Simulation of four stroke engines, Gordon P Blair, SAE International
5. Gasoline Engine Management, Bosch handbook,2nd edition, Professional Engineering Publication
6. Internal Combustion Engines, C.R. Ferguson & A.R. Kirkpatrick,Delhi,2001

ADVANCED AIR CONDITIONING, HEATING AND VENTILATION
Elective-II (502105-B)

Teaching Scheme:
Lecture: 3 hrs/week

Examination
Paper: 100 Marks
Paper Duration: 3 hrs.

1. Applied Psychrometry, Psychrometric processes using chart
2. **Load Estimation**: 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.
3. **Air Distribution**: 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. VAV.
4. **Sound Control**: Definitions of various terms like level, pitch, attenuation, frequency, sources of noise in air conditioning plants, design procedure for noise prevention, noise and vibration study and elimination techniques (description only).
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.
6. **Direct and Indirect Evaporative Cooling**: Basic psychometric of evaporative cooling, types of evaporative coolers, design calculations, indirect evaporative cooling for tropical countries.
7. **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
8. **Air conditioning systems**: 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). VRF.
9. **Standards and Codes**: ASHRAE/ARI, BIS standards study and interpretation, ECBC, NBC codes

(* Question Paper- 50% to 60% of maximum marks are kept for the questions asked on System Design and not any theory.)

Term Work:

1. Design Project for system selection, load estimation, duct design, equipment selection, Control systems, cost estimation, lay out diagrams (line sketches) for any one application from: Hospital, Hotel, Auditorium, Computer lab, Operation Theater etc.
2. Draw Psychrometric chart for a non standard Pressure

Recommended Books:

1. ASHRAE Handbooks
2. ISHRAE Handbook.
3. Handbook of Air Conditioning System Design, Carrier Incorporation, McGraw Hill Book Co., USA.
4. Trane air conditioning manual,
5. Refrigeration and Air conditioning, ARI Prentice Hall, New Delhi.
6. Norman C. Harris, Modern air conditioning
7. Jones W. P., Air conditioning Engineering, Edward Arnold Publishers Ltd, London, 1984.
8. Jones W. P., Air conditioning Engineering - Applications, Edward Arnold Publishers Ltd, London, 1984
9. Hainer R. W., Control System for Heating, Ventilation and Air conditioning, Van Nastrand Reinhold Co., New York, 1984.
10. Refrigeration and Air conditioning- C P Arora, Tata McGraw Hill Publication, New Delhi.
11. McQuiston, Faye; Parker, Jerald; Spitler, Jeffrey 2000, Heating, Ventilating and Air Conditioning-Analysis and Design, 5th ed. John Wiley & Sons.

Conventional Power Plants
Elective II (502105-C)

Teaching Scheme: **Examination**
Lecture: 3 hrs/week **Paper: 100 Marks**
Paper Duration: 3 hrs.

Steam Turbines: Power plant cycles, cycle analysis and design losses in steam turbines, Performance at various loads, governing, operation and management

Fluidized bed combustion, sizing of power plant components: steam generator, condenser, cooling tower, turbines etc.

Nuclear reactor fundamentals, Nuclear Power plants types, safety in nuclear power plants, enrichment of fuels, heavy water facilities.

Combined cycle power plants, cogeneration plants, Gas Turbine power plant, combustor, pollution control techniques, diesel engine power plants.

Hydropower and its constraints, environmental and social impacts, selection of components, Mini and micro Hydal power plants

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, Saftey in power plants.

TERM WORK

1. Visit to hydro power plant and report on it.
2. Visit to thermal power plant, flow diagram and component selection report
3. Instruments used in the control room of power plant, layout and operational details.
4. Exergy analysis of a steam power plant.

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 Well Books, 1991

5. Standard Handbook of Power plant Engineering, Thomas C Elliot, Robert C Swanekamp, Kao Chen, McGraw Hill Professional, 1997
6. Wet steam turbines for Nuclear Power plants, Aleksander Lejzerovic, Penn Well Books, 2005.
7. TMI 25 Years Later: the Three Mile Island nuclear power plant accident and its impact, Bonnie Anne Osif, Anthony Baratta, Thomas W Conkling, Penn State Press, 2004.

*** Question Paper- 50% to 60% of marks are kept for the quantitative questions)**

Advanced Gas Dynamics
Elective II (502105-D)

Teaching Scheme:
Lecture: 3 hrs/week

Examination
Paper: 100 Marks
Paper Duration: 3 hrs.

1. **Review of Elementary Principles**
   Mathematical Concepts, Thermodynamic Concepts for Control Mass Analysis
2. **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.
3. **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.
4. **Varying Area Adiabatic Flow**
   General Fluid Flow without Losses, Perfect Gas Flow with Losses, The * reference concept, Isentropic Table, Nozzle operation and performance, Diffuser performance.
5. **Standing Normal Shocks**
   Shock analysis for a general fluid, Working equations for perfect gases, Normal Shock table, Shocks in Nozzles, Supersonic wind tunnel.
6. **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.
7. **Prandtl-Meyer Flow**
   Argument for isentropic turning flow, Analysis of Prandtl–Meyer flow, Prandtl-Meyer function, overexpanded and underexpanded nozzles, supersonic airfoils.
8. **Fanno Flow**
   Analysis for a General fluid, Working equations for perfect gases, reference state and Fanno table, applications, correlation with shocks, friction chocking.
9. **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.
10. **Real Gas Effects**
    Behavior of real gases, Equations of states and compressibility factors, semiperfect gas behavior.

Recommended Books:

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,

Advanced Heat Transfer
(502108)

Teaching Scheme:
Lecture: 3 hrs/week

Examination
Paper: 100 Marks
Paper Duration: 3 hrs.

1. 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. Numerical methods for fin analysis.
2. Transient Conduction: Lumped capacitance and its validity, General lumped capacitance analysis, spatial effects. Problems related with conventional geometries.
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.
4. Forced Convection (External Flow)
   Empirical method. Flat plate in parallel flow. The Blasius solution(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: turbulent flow in circular tubes, for non circular tubes. Heat transfer enhancement, Passive, active and compound techniques.
5. 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.
6. Boiling and Condensation
   Boiling modes, the boiling curve, modes of pool boiling, correlations. Forced convection boiling. Two phase flow.
   Condensation: Physical mechanisms, laminar film condensation on a vertical plate. Turbulent film condensation, film condensation on radial systems, film condensation in horizontal tubes, on banks of tubes. Dropwise condensation correlations.

7. Thermal 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.
8. Cooling of Electronic Equipment
   Introduction: Manufacturing, Chip carrier, PCB's, the enclosure, Cooling load of electronic equipment, thermal environment, electronics cooling in different applications. Conduction cooling, conduction in chip carriers and PCB's. Heat frames, Air cooling, Cooling of PC's, Liquid cooling, Immersion cooling. Ablative , transpiration and high speed cooling

Assignments:

1. Fluidized bed combustion.
2. Heat pipes
3. Numerical method in heat conduction & convection.
4. Combined heat transfer.
5. Passive heat transfer augmentation techniques.
6. Electronic cooling
7. One problem on network method (Radiation).
8. Heat transfer during melting and solidification.

Reference books:

1. Incropera and Dewitt. Fundamentals of heat and mass transfer. John Wiley and sons.
2. Yunus Cengel: Heat transfer - an practical application. Tata Mc Graw Hill.
3. M.N. Ozisik - Heat transfer a basic approach - Mc Graw Hill Int.
4. A Bejan – Convective heat transfer.- John Wiley and sons.
5. J.P. Holman- Heat transfer, Mc Graw Hill, Int.
6. S.P. Sukhatme, Heat transfer, University Press

Measurement Techniques & Data Analysis
(502109)

Teaching Scheme:
Lecture: 3 hrs/week

Examination
Paper: 100 Marks
Paper Duration: 3 hrs.

1) Introduction to measurements for scientific and engineering application need and goal. Broad category of methods for measuring field and derived quantities.

2) Principles of measurement, parameter estimation, regression analysis, correlations, error estimation and data presentation, analysis of data

3) 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.

4) Measurement of derived quantities, torque, power, thermo physical properties, radiation and surface properties.

5) Analytical methods and pollution monitoring, mass spectrometry, chromatography, spectroscopy

6) Basics of P, PI, PID controllers, pneumatic and hydraulic controllers, electronic controllers, applications to machine tools, furnaces, material handling etc

Exercise/Assignment

1) Calibration of pressure gauge
2) Computer aided experimentation for temperature measurement.
3) Design of control system for boiler/compressor/pumps/turbines
4) Problem of analysis of data and error estimation.

Reference Books

1) Doebelin E.O: Measurement Systems-Application and Design, McGraw Hill Publication Co.
2) Beckwith TG. N. Lewis Buck and Marangoni R.D: Mechanical Measurements, Narosa Publishing House, New Delhi
3) Liptak B.G. Instrument Engineers' Handbook
4) Bolton W, Mechatronics-Electronics Control Systems in Mechanical and Electrical Engg.
5) Modern Electronic Instrumentation and Measurement Technique by A.D. Helfrick and W.D. Cooper
6) Johnson C.D., Process Control Instrumentation
7) J.P.Holman: Experimental Methods For Engineers, McGraw Hill International Edition, Seventh Edition

*** Question Paper- 50% to 60% of marks are kept for the quantitative questions)**

Advanced Fluid Mechanics
(502110)

Teaching Scheme:
Lecture: 3 hrs/week

Examination
Paper: 100 Marks
Paper Duration: 3 hrs.

1. Governing Equations: mass conservation in differential and integral forms, Flow kinematics, and Momentum equation: substantial derivative, differential and integral form, stress tensor, stress strain relations, Ideal Fluid flow concepts.

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.

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.

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.

5. 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

6. 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.

Lab Experiments:

1. Flow over a cylinder/sphere at different Re. Pressure variation over the body and drag estimation
2. Flow past an aerofoil: Pressure measurements, calculation of lift

3. Flow through a converging-diverging nozzle: subsonic and supersonic flows

4. Friction factor determination: incompressible flow through pipes/ducts of variable cross-section
5. Laminar/Turbulent boundary layer over a flat plate.

Assignments:

1. Numerical simulation of flow through a c-d nozzle
2. Testing of turbulence models
3. Blasius / Falkner-Skan solutions.

References:

1. Advanced Fluid Mechanics, G. Biswas and K. Muralidhar

2. Viscous Fluid Flow, F. M. White

3. Boundary Layer Theory, H. Schlichting

4. Fluid Mechanics, Cengel, Tata McGraw Hill

5. Fluid Mechanics, F.M. White, McGraw Hill Int.

I.C. Engines- Fuels and Combustion
Elective-III (502111-A)

Teaching Scheme:
Lectures: 3 hrs/week

Examination Scheme:
Paper: 100 Marks
Paper Duration: 3 hrs.

1) Fuels For S.I. and C.I. Engines: Qualities of SI & CI engine fuels, rating of SI & CI engine fuels, fuel additives for SI & CI engines

2) Alternate Fuels: Solid fuels, liquid fuels, gaseous fuels ,hydrogen engines, other possible fuels

3)Combustion & Combustion Chambers In SI Engines: Combustion in SI engine, stages of combustion, phenomenon of detonation, effect of engine, variables on detonation, combustion chambers for SI engines

4)Combustion & Combustion Chambers In CI Engines: Combustion in CI engine, Stages of combustion, factors affecting delay period, the phenomenon of knock in CI engine ,combustion chambers for CI engines

5)Supercharging & Turbocharging : Purpose of supercharging, supercharging of SI & CI engines and its limitations, methods of supercharging ,supercharging arrangements , turbochargers , methods of turbo charging & its limitations

6)Fuel/Air Mixture Requirements: For steady running, Optimum fuel/Air ratios, idling and low load, normal and maximum power range, transient mixture requirements, effect of operating variables on mixture requirements, mixture requirements for CI engines, Modern trends in fuels and combustion

Experiments (Any Three)

1. Study of fuel systems for S.I. engines
2. Study of fuel systems for C.I. engines
3. Determination of stoichiometric Air: Fuel ratio for gasoline and Diesel
4. Determination of stoichiometric Air: Fuel ratio for Alternate fuel
5. Visit to Industry/Automobile workshop

References

1. The Internal Combustion Engine in Theory and Practice Volume I & II by Charles Fayette Taylor, The MIT Press
2. Internal Combustion Engines- V Ganesan, 2nd edition, Tata McGraw Hill
3. Alternate fuels Guidebook, Richard L. Bechtold, SAE International
4. Automotive fuels and fuel systems, Vol. I & II, T. K. Garret, SAE International
5. Internal Combustion Engines, Haywood, Tata Mc-Graw Hill
6. Engineering Fundamentals of The Internal Combustion Engine, Willard W. Pulkrabek, Pearson Education

Cryogenic Engineering
Elective-III (502111-B)

Teaching Scheme:
Lecture: 3 hrs/week

Examination
Paper: 100 Marks
Paper Duration: 3 hrs.

1. Refrigeration and liquefaction principals; Joule Thomson effect and inversion curve; Adiabatic and isenthalpic expansion with their comparison.

2. Properties of cryogenic fluids; Properties of solids at cryogenic temperatures; Superconductivity.

3. Gas liquefaction systems: Recuperative – Linde – Hampson, Claude, Cascade, Heylandt, Kapitza, Collins, Simon; Regenerative – Stirling cycle and refrigerator, Slovay refrigerator, Gifford-McMahon refrigerator, Vuilleumier refrigerator, Pulse Tube refrigerator; Liquefaction of natural gas.

4. Cryogenic insulation: Vacuum insulation, Evacuated porous insulation, Gas filled Powders and fibrous materials, Solid foams, Multilayer insulation, Liquid and vapour Shields, Composite insulations.

5. Storage of cryogenic liquids; Design considerations of storage vessel; Dewar vessels; Industrial storage vessels; Storage of cryogenic fluids in space; Transfer systems and Lines for cryogenic liquids; Cryogenic valves in transfer lines; Two phase flow in Transfer system; Cool-down of storage and transfer systems.

6. Cryogenic instrumentation: Measurement of strain, pressure, flow, liquid level and Temperature in cryogenic environment; Cryostats.

7. 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; System Optimization.

8. Magneto-caloric refrigerator; ^{3}He-^{4}He Dilution refrigerator; Cryopumping; Cryogenic Engineering applications in energy, aeronautics, space, industry, biology, preservation Application of Cryogenic Engineering in Transport

TERM – WORK / EXPERIMENTS

1. Visit to Nitrogen liquefaction plant.
2. Design of a recuperative cryogenic heat exchanger for a given liquefaction system.
3. Calibration of a cryogenic temperature-measuring instrument.
4. Trial / Design of Stirling cycle refrigerator.
5. Trial / Design of Pulse tube refrigerator.

RECOMMENDED BOOKS

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.

Non-Conventional Power Plants

Elective III (502111-C)

Teaching Scheme:
Lecture: 3 hrs/week

Examination
Paper: 100 Marks
Paper Duration: 3 hrs.

Potential of renewable energy sources, renewable electricity and key elements, Global climate change, CO_2 reduction potential of renewable 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.

Wind energy: Wind energy potential measurement, wind electric generator component design, economics and demand side management, energy wheeling, and energy banking concepts.

Biogas: properties of biogas (Calorific value and composition), biogas plant technology and status

Other plants: Fuel cell based power plants, tidal and wave energy plant design, OTEC power plants.
Geothermal energy: hot springs and steam ejection site selection, power plants, and economics.
Environmental impacts, Economic and social considerations, Financing mechanisms, Carbon credits, clean development mechanisms

TERM WORK

1. Visit to a biogas plant and its report.
2. Design of photovoltaic plant for agricultural applications.
3. Trial on solar concentrator/CPC/Evacuated Tube Collector system.
4. Analysis of a wind farm system.

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.Goswami, F.Kreith and J.F.Kreider, 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.

5. Mukund R Patel, Wind and Solar Power Systems, CRC Press, 1999.
6. J F Manwell, J.C.McGowan, A.L.Rogers, Wind Energy Explained: Theory, Design and Application, John Wiley and Sons, May 2002.
7. R D Begamudre, Energy Conversion Systems, New Age International (P) Ltd., Publishers, New Delhi ,2000.

***(Question Paper- 50% to 60% of marks are kept for the quantitative questions)**

Heat Exchanger System Design and Performance- Elective-IV (502112-A)

Teaching Scheme:
Lecture: 3 hrs/week

Examination
Paper: 100 Marks
Paper Duration: 3 hrs.

1. Basic design methods for heat exchanger- Design of shell and tube type heat exchanger, TEMA code.
2. Plate heat exchanger, Compact heat exchanger, Codes of mechanical design of heat exchanger.
3. Computerized methods for design and analysis of heat exchanger.
4. Performance enhancement of heat exchanger, fouling of heat exchanger. Testing, evaluation and maintenance of heat exchanger.
5. Power plant heat exchanger, heat exchanger for heat recovery at low, medium and high temperatures.
6. Regenerators, Principles of boiler design, recuperators, matrix heat exchanger and heat pipe exchanger.
7. Furnaces, Radiative heat exchangers.
8. Recent developments in heat exchangers

Term Work

- Performance of heat exchanger
- Group project on design of heat exchanger for a particular application based on "real world" data
- Visit to heat exchanger manufacturing facility

References

- Heat Transfer by F. Incropera and D. DeWitt or other basic undergraduate heat transfer textbook.
- Compact Heat Exchangers by W. Kays and A. London, National Press.
- Compact Heat Exchangers by R. Shah, A. Kraus, D. Metzger, Hemsisphere Publishing Corporation.
- Heat Exchanger Design By Fraas, Arthur P. Fraas, M Necati Özisik, Wiley-IEEE.
- Heat exchanger, Design, rating and Selection, Sadik Kakac, CRC Press
- Heat Exchangers Thermal Hydraulic Fundamentals and Design by S. Kakac, A. , Bergles, F. Mayinger, McGraw-Hill Book Company.
- Automotive Heating and Air Conditioning by Tom Birch, Prentice Hall

***(Question Paper- 50% to 60% of marks are kept for the quantitative questions)**

Computational Fluid Dynamics
Elective IV (502112-B)

Teaching Scheme:
Lecture: 3 hrs/week

Examination
Paper: 100 Marks
Paper Duration: 3 hrs.

1. **Introduction to CFD**
   Historical background, Impact of CFD
2. **The Governing Equations of Fluid Dynamics**
   Derivation, Discussion of physical meanings and Presentation of forms particularly suitable to CFD.
3. **Mathematical Behavior of Partial Differential Equations:**
   Impact on CFD
4. **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.
5. **Grids with Appropriate Transformations**
   Adaptive grids and unstructured meshes.
6. **A 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.
7. **Numerical Solutions of Quasi-One-Dimensional Nozzle Flows**
8. **Numerical Solution of a 2D Supersonic Flow**
   Prandtl-Meyer Expansion Wave
9. **Incompressible Couette Flow**
   Solution by implicit method and the pressure correction method.
10. **Supersonic Flow over a Flat Plate**
    Numerical Solution by solving complete Navier Stokes equation.

Recommended Books:

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]