File Ref.No.11704/GA - IV - E2/2013/CU

UNIVERSITY OF CALICUT

Abstract

Faculty of Engineering - M.Tech Course in Energy Systems Analysis and Design - Scheme and Syllabus - Approved - Implemented- With effect from 2012 Admission - Orders issued.

UNIVERSITY OF CALICUT (G & A - IV - E)

U.O.No. 1350/2013/CU   Dated, Calicut University.P.O, 24.04.2013

Read:-1. Letter No. C1/4651/2010 dated 20-12-2012 from the Principal, Government Engineering College, Kozhikode.

2. This office Letter No. 325/GA - IV - E1/2013/CU dated 18-01-2013.

3. Item No. I(a) of the minutes of the meeting of the Board of Studies in Engineering(PG), held on 11-02-2013.

4. Orders of the Vice Chancellor at para No.29 of File No. 5291/GA - IV - 2013/CU on 01-04-2013.

ORDER

Vide paper read as 1st above, draft Scheme and draft Syllabus, prepared by a panel of Subject Experts, for the proposed M.Tech. Course in Energy Systems Analysis and Design were forwarded by the Principal, Government Engineering College, Kozhikode for approval.

Vide paper read as 2nd above, the draft Scheme and draft Syllabus for the proposed M.Tech Course in Energy Systems Analysis and Design was forwarded to the Chairman, Board of Studies in Engineering(PG) for remarks on the drafts. The draft Syllabus was placed in the meeting of the Board of Studies in Engineering(PG) held on 11-02-2013.

Vide paper read as 3rd above, The Board of Studies in Engineering (PG) held on 11-02-2013, unanimously decided to approve the Scheme and Syllabus of the M.Tech. Course in Energy Systems Analysis and Design and to follow the Eligibility Criteria for admission to the Course to be as per the “Clause 2 of M.Tech. Degree Course Regulations-2010” and to recognise the following eligible B.Tech Degree course for the admission to the M.Tech Course in Energy Systems Analysis and Design.

1.B.Tech Degree in Mechanical Engineering

Having Considered the matter in detail, vide paper read as 4th above, Sanction has been accorded by the Vice Chancellor to implement the Scheme and Syllabus of the M.Tech. Course in Energy Systems Analysis and Design with effect from 2012 admission, to fix the Clause 2 of M.Tech. Degree Course Regulations-2010 to be the eligibility criteria and to recognise the following B.Tech. Degree Course for the admission to the Course, subject to ratification by the Academic Council.

1	B.Tech Degree in Mechanical Engineering

Orders are issued accordingly.

Moideen Kutty C.E

Deputy Registrar

To

The Principal, Govt. Engineering College, Kozhikode.

Copy to:- PS to VC/PA to Reg./PA to CE/DR; AR, M.Tech Branch/CDC Branch./Dean, Faculty of Engineering.

Forwarded / By Order

Section Officer

UNIVERSITY OF CALICUT

M.Tech.

in

Energy Systems Analysis and Design

Curriculum, Scheme of Examinations and Syllabi

(With effect from 2012 admissions)

SCHEME OF EXAMINATIONS

Semester - I

Code	Subject	Hours per week			Marks		Total Marks	Sem-end exam duration - Hrs	Credits
		L	T	P/D	Intl.	Sem-end			
MEA10 101	Advanced Engineering Mathematics	3	1	-	100	100	200	3	4
MEA10 102	Energy Conversion Systems	3	1	-	100	100	200	3	4
MEA10 103	Advanced Fluid Mechanics and Heat Transfer	3	1	-	100	100	200	3	4
MEA10 104	Turbo Machinery	3	1	-	100	100	200	3	4
MEA10 105	Elective-I	3	1	-	100	100	200	3	4
MEA10 106(P)	*Thermal Systems Lab/Mini project*	-	-	*2*	*100*	-	*100*	-	*2*
MEA10 107(P)	*Seminar*	-	-	*2*	*100*	-	*100*	-	*2*
	Departmental Assistance	-	-	*6*	-	-	-	-	-
TOTAL		15	5	10			1200		24

Electives -I

1	MEA10 105 (A)	Computational Methods
2	MEA10 105 (B)	Soft Computing Techniques
3	MEA10 105 (C)	Aerodynamics
4	MEA10 105 (D)	Maintenance Engineering and Management
5	MEA10 105 (E)	Research Methodology

Semester – II

Code	Subject	Hours per week			Marks		Total Marks	Sem-end exam duration- Hrs	Credits
		L	T	P/D	Intl.	Sem-end			
MEA10 201	Design of Equipments for Energy Conversion Systems	3	1	-	100	100	200	3	4
MEA10 202	Materials Engineering & Tribology for Energy Conversion Systems	3	1	-	100	100	200	3	4
MEA10 203	Advanced Instrumentation Systems	3	1	-	100	100	200	3	4
MEA10 204	Elective-2	3	1	-	100	100	200	3	4
MEA10 205	Elective-3	3	1	-	100	100	200	3	4
MEA10 206(P)	*Seminar*	-	-	2	100	-	100	-	2
MEA10 207(P)	*Mechanical Engineering Design Lab/Mini Project*	-	-	2	100	-	100	-	2
	Departmental Assistance		-	6	-	-	-	-	-
TOTAL		15	5	10			1200		24

Electives –II

1	MEA10 204 (A)	Hydropower Systems
2	MEA10 204 (B)	Advanced Thermodynamics and Combustion
3	MEA10 204 (C)	Optimization Techniques
4	MEA10 204 (D)	Cryogenics
5	MEA10 204 (E)	Refrigeration Engineering

Electives –III

1	MEA10 205 (A)	Solar Engineering
2	MEA10 205 (B)	Renewable Energy Technology
3	MEA10 205 (C)	Nuclear Engineering
4	MEA10 205 (D)	Industrial Noise Control
5	MEA10 205 (E)	Nano Science and Technology

Semester – III

Code	Subject	Hours per week			Marks			Total Marks	Sem-end exam duration - Hrs	Credits
		L	T	P/D	Intl.		Sem-end			
MEA10 301	Elective-4	3	1	-	100		100	200	3	4
MEA10 302	Elective-5	3	1	-	100		100	200	3	4
MEA10 303(P)	*Industrial Training*	-	-	-	50		-	50	-	1
					Guide	EC*				
MEA10 304(P)	*Masters Research Project(Phase -I)*	-	-	22	150	150	-	300	-	6
TOTAL		6	2	22	500			750		15

NB: The student has to undertake the departmental work assigned by HOD
*EC – Evaluation Committee

Electives –IV

1	MEA10 301 (A)	Manufacturing Methods for Energy Conversion Systems
2	MEA10 301 (B)	Energy Policies for Sustainable Development
3	MEA10 301 (C)	Energy Efficient Buildings
4	MEA10 301 (D)	Reliability Engineering
5	MEA10 301 (E)	Vibration Analysis and Control

Electives –V

1	MEA10 302 (A)	Co-generation and Waste Heat Recovery System
2	MEA10 302 (B)	Wind Energy and its Utilization
3	MEA10 302 (C)	Electrical Energy Systems and Management
4	MEA10 302 (D)	Energy Conservation and Heat recovery System
5	MEA10 302 (E)	Energy Modeling, Economics and Management

Semester – IV

Code	Subject	Hours per week			Internal Marks		Sem-end exam.		Total Marks	Credits
		L	**T**	**P/D**	**Guide**	**Evaluation committee**	**Extl. Guide**	**Viva-Voce**		
MEA10 401(P)	*Masters Research Project (Phase -II)*	-	-	30	150	150	150	150	600	12
TOTAL				30	150	150	150	150	600	12

NB: The student has to undertake the departmental work assigned by HOD

MEA10 101 ADVANCED ENGINEERING MATHEMATICS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To enable to do statistical techniques in engineering problems and to provide necessary back ground in linear algebra and PDE needed for analyzing problems in mechanical engineering.*

Module I (13 hours)

Vector spaces, Basis, Dimension, Inner product spaces, Gram-Schmidth Process, Linear transformations, Range and Kernel, Isomorphism, Matrix of transformations and change of Basis.

Module II (13 hours)

Power series solutions about ordinary point, Legendre equation and Legendre polynomials,Solutions about singular points; The method of Frobenius, Bessel equation and BesselFunctions. Sturm-Liouville problem and Generalized Fourier series.

Module III (13 hours)

First order PDEs, Linear equations, Lagrange method, Cauchy method, Charpits method, Jacobi method. Second order PDEs, Classifications, Formulation and method of solutions of Wave equation, Heat equation and Laplace equation.

Module IV (13 hours)

Line, area and volume integrals, Spaces of N-dimensions, coordinate transformations, covariant and mixed tensors , fundamental operation with tensors, the line element and metric tensor, conjugate tensor, Christoffel's symbols , covariant derivative.

References:

1. Lay, D. C., Linear Algebra and its Applications, Addison Wesley, 2003.
2. Florey, F. G., Elementary Linear Algebra with Application, Prentice Hall, 1979.
3. Hoffman, K. and Kunze, R., Linear Algebra, Prentice Hall of India, 1971.
4. Bell, W. W., Special Functions for Scientists and Engineers, Dover Publications, 2004.
5. Sokolnikoff, I. S. and Redheffer, R. M., Mathematics of Physics and Modern Engineering, Second Edition,McGraw-Hill, 1966.
6. Sneddon, I., Elements of Partial Differential Equations, McGraw-Hill,1985.
7. Tychonov, A. N. and Samarskii, A. A., Partial Differntial Equations of Mathematical Physics, Holden-Day, 1964.
8. Spain, B., Tensor Calculus, Third Edition, Oliver and Boyd, 1965.
9. Irving, J. and Mullineux, N., Mathematics in Physics and Engineering, Academic Press, 1959.
10. Ross, S. L., Differential Equations, Third Edition, John Wiley & Sons, 2004.
11. Pipes, L. A. and Harwill, L. R., Applied Mathematics for Engineers and Physicists, Third Edition, McGraw-Hill, 1970.
12. Akivis,M.A.and Goldberg, V.V., An Introduction to Linear Algebra and Tensors, Dover Publications, 1997.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 102 ENERGY CONVERSION SYSTEMS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To understand the principles and operations related to Energy Conversion Systems.*

Module I (13 hours)

Classification of energy sources - Utilization, economics and growth rates - Fossil fuels,nuclear fuels and solar energy - Combustion calculations - Conventional thermal powerplant design and operation - Superheat, reheat and regeneration - Other auxiliaries of thermal plant - High-pressure boilers - Steam generator control

Module II (13 hours)

Gas turbine and combined cycle analysis – Inter-cooling, reheating and regeneration-gas turbine cooling -design for high temperature - Combined cycles with heat recovery boiler – Combined cycles with multi-pressure steam - STAG combined cycle power plant - Influence of component efficiencies on cycle performance.

Module III (13 hours)

Solar energy – The Sun – Production and transfer of solar energy — Solar thermal collectors –General description and characteristics –Solar concentrators –Energy from biomass – Sources of biomass – Different species – Conversion of biomass into fuels – Energy through fermentation – Pyrolysis, gasification and combustion – Aerobic and anaerobic bio-conversion –Properties of biomass .Wind energy – Principles of wind energy conversion – Site selection considerations –Wind power plant design –Types of wind power conversion systems – Operation, maintenance and economics – Geothermal energy –Availability, system development and limitations – Ocean thermal energy conversion – Wave and tidal energy –Scope and economics – Introduction to integrated energy systems.

Module IV (13 hours)

Energy efficiency - Energy accounting, monitoring and control – Thermal and Electricity audit instruments – Energy consumption models - Specific Energy Consumption – ECO assessment and Evaluation methods – Transformer loading/efficiency analysis – Feeder loss evaluation - Lighting - Energy efficient light sources - Domestic/commercial /industrial lighting - Lighting controls - Energy conservation in lighting schemes - Luminaries - Case studies.

References:

1. El-Wakil M. M., Power Plant Technology, McGraw Hill, 1985
2. Culp Jr A. W., Principles of Energy Conversion, McGraw Hill, 2001
3. Sorensen ,H. A., Energy Conversion Systems, J. Wiley, 1983
4. Morse, T. F., Power Plant Engineering, Affiliated East West Press, 1978
5. Saigh, A.A.M., (Ed): Solar Energy Engineering, Academic Press, 1977
6. Kreith, F., and J.F. Kreider, Principles of Solar Engineering, McGraw Hill, 1978
7. Mittal , K.M.,Non-conventional Energy Systems - Principles, Progress and Prospects, Wheeler Publications, 1997.
8. Turner, W.C. , Energy Management Handbook, 2e, Fairmont Press, 1993.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 103 ADVANCED FLUID MECHANICS AND HEAT TRANSFER

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To make the students understand the concepts & broad principles of fluid mechanics and heat transfer*

Module I (13 hours)
Review of fundamental concepts – continuum, control volume, Eulerian and Lagrangian methods of description of fluid flow; Reynolds transport equation – integral and differential forms of continuity, momentum, and energy equations, Navier-Stokes equations and boundary conditions; Non-dimensionalization of equations and order of magnitude analysis, dimensionless parameters and their significance; classification of flows based on the characteristic Reynolds number; equations for low and high Reynolds number flows.

Module II (13 hours)
Exact solution of incompressible Navier-Stokes equations – Couette flow, flow between rotating cylinders, Stokes problems, stagnation point flow, flow near a rotating disk, fully developed flow through ducts; Low Rerynolds number flows, use of vorticity and stream
function, creeping flow past a sphere, hydrodynamic theory of lubrication.

Module III (13 hours)
Introduction- Review of heat transfer fundamentals-Transient conduction and extended surface heat transfer- Brief review of Steady Laminar and Turbulent Heat Transfer in External and Internal Flows - Liquid metal heat transfer- Heat transfer at high Speeds.

Module IV (13 hours)
Natural convection- Combined free and forced convection -Characteristic of thermal radiation- Radiation laws- Radiation properties- Radiation heat exchange between black/gray surfaces with and without participating medium- Radiation in Enclosures- Gas Radiation - Combined conduction, convection and radiative heat exchange.

References:
1. White, F. M., Viscous Fluid Flow, Third Edition, McGraw-Hill, 2006
2. Schlitching, H., Boundary Layer Theory, Seventh Edition, McGraw-Hill, 1987.
3. Muralidhar, K. and Biswas, G., Advanced Engineering Fluid Mechanics, Second Edition, Narosa Publishing House, 2005.
5. Kays and Crawfard., Convective heat and mass transfer, Mc-Graw Hill,1966.
6. Incorepera F.P and Dewitt, Fundamentals of heat and mass transfer, Wiley Eastern
7. Holman .J.P., Heat and mass transfer, Tata Mcgraw Hill.
8. Siegel and Howell, Thermal radiation Heat transfer, McGraw Hill, 1966.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 104 TURBOMACHINERY

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives:

To make the students understand the concepts & broad principles of hydro and thermal turbo machines

Module I (13 hours)

Definition and classification of turbomachines; principles of operation; specific work and its representation on T-s and h-s diagrams; losses and efficiencies; energy transfer in turbo machines; Euler equation of turbo machinery.

Module II (13 hours)

Flow mechanism through the impeller – velocity triangles, ideal and actual flows, slip and its estimation; degree of reaction - impulse and reaction stages; significance of impeller vane angle.

Module III (13 hours)

Similarity; specific speed and shape number; cavitations in pumps and turbines; performance characteristics of pumps and blowers; surge and stall; thin aerofoil theory;
cascade mechanics

Module IV (13 hours)

Steam turbines - flow through nozzles, compounding, effect of wetness in steam turbines; gas turbines; hydraulic turbines – Pelton, Francis and Kaplan turbines, draft tube, performance and regulation of hydraulic turbines.

References:

1. Yahya, S. M., Turbines, Compressors and Fans, Tata McGraw-Hill, 1983.
2. Gopalakrishnan, G. and Prithviraj, D., Treatise on Turbo machines, Schitech Publications, 2002
3. Shepherd, D. G., Principles of Turbomachinery, Macmillan Publishing Company, 1957.
4. Csanady, G. T., Theory of Turbomachines, McGraw-Hill, 1964.
5. Dixon, S. L., Fluid Mechanics, Thermodynamics of Turbomachinery, Third Edition, Pergamon Press, 1978.
6. Nechleba, M., Hydraulic Turbine, Arita, 1957.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 105(A) COMPUTATIONAL METHODS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To understand the principles of numerical methods for solving algebraic equations and various engineering problems.*

Module 1 (13 hours)

Errors in numerical calculations: Sources of errors, significant digits and numerical instability – numerical solution of polynomial and transcendental equations – bisection method – method of false position – Newton-Raphson method – fixed-point iteration – rate of convergence of these methods – iteration based on second degree equation – the Muller's method – Chebyshev method – Graeffe's root squaring method for polynomial equations – Bairstow method for quadratic factors in the case of polynomial equations.

Module II (13 hours)

Solutions of system of linear algebraic equations: Direct methods – Gauss elimination and Gauss-Jordan methods – Crout's reduction method – error analysis – iterative methods – Jacobi's iteration – Gauss-Seidal iteration – relaxation method – convergence analysis – solution of system of nonlinear equations by Newton-Raphson method – power method for the determination of Eigen values – convergence of power method. Solution of tri-diagonal system – Thomas algorithm.

Module 111 (13 hours)

Solution of steady state and transient heat conduction equations –explicit, implicit, Crank-Nicholson schemes-conservation form and conservative property of partial differential and finite difference equations; consistency, stability and convergence for marching problems; discrete perturbation stability analysis, SMPLE, SIMPLER and other algorithms. Grid generation methods

Module IV (13 hours)

Introduction: Finite element method as a numerical tool for design – basic concepts – formulation procedures – historical development – current trends – free and commercial FE packages. FE modelling - Direct approach: 1-D bar element – element stiffness – assembly of elements – properties of [K] matrix – treatment of boundary conditions – temperature effects – stress computation – support reaction – simple problems. Analogous (1-D) problems of torsion, heat conduction and laminar pipe flow. Beam element: Beam relationships – 1-D beam element FE formulation - element stiffness matrix – load considerations – boundary conditions – member end forces.

References

1. Anderson, D. A, Tannehill, J. C., and R. H. Pletcher, R. H., Computational Fluid Mechanics and Heat Transfer, Second Edition, Taylor & Francis, 1995.
2. Muraleedhar, K. and Sundararajan, T. (eds.), Computational Fluid Flow and Heat Transfer, Second Edition, Narosa Publishing House, 2003.
3. Patankar, S. V., Numerical Heat Transfer and Fluid Flow, Hemisphere, 1980.
4. Hoffmann Klaus, A., Computational Fluid Dynamics for Engineers – Volume 1, Engineering Education Systems, Wiehita.
5. Versteeg, H. K. and W. Malalasekera, W., An Introduction to Computational Fluid Dynamics: The Finite Volume Method, Addison Wesley – Longman, 1995.
6. Hornbeck, R. W., Numerical Marching Techniques for Fluid Flows with Heat Transfer,NASA, SP-297, 1973.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 105(B) SOFT COMPUTING TECHNIQUES

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To understand the principles of neural networks, fuzzy logic and genetic algorithms and its Engineering application.*

Module I - (12 Hours)

Artificial Intelligent systems – Neural Networks, Fuzzy Logic and Evolutionary Programming concepts. Artificial Neural Networks – Biological neural networks – Model of an artificial neuron – Comparison between biological neuron and artificial neuron – Basic models of artificial neural networks – Learning methods – Activation function and terminologies of ANN – McCulloch Pitts Neuron – Linear Separability – Hebb network – Perceptron Networks, Adaline, Madaline.

Module II – (12 Hours)

Back propagation Networks: Architecture – Multi layer perceptron – Back propagation learning – Input layer, Hidden Layer, Output Layer computations, Calculation of error, Training of ANN, Back propagation Algorithm, Momentum and Learning rate, Selection of various parameters in BP networks – Radial Basis Function Networks. Variations in standard BP algorithms – Decremental iteration procedure, Adaptive BP, GA based BP, Quick prop training, Augmented BP networks, Sequential learning Approach for single hidden layer Neural networks.

Module III- (14 Hours)

Fuzzy sets and crisp sets-Fuzzy sets – Fuzzy set operations-Fuzzy relations – Membership functions – Features of the membership function – Methods of membership value assignment – Defuzzification – Defuzzification methods – Fuzzy Rule Base and approximate reasoning – Truth values and tables in fuzzy logic, Fuzzy propositions, Formation of rules, Decomposition of rules, Aggregation of fuzzy rules – Fuzzy Inference Systems – Construction and Working Principle of FIS – Methods of FIS – Mamdani FIS and Sugeno FIS – Fuzzy Logic Control Systems – Architecture and Operation of FLC System – FLC System Models – Application of FLC Systems.

Module IV – (14 Hours)

Genetic Algorithms – Basic Concepts – Creation of off-springs – Working Principle – Encoding – Fitness function – Reproduction – Roulette – Wheel Selection, Boltzmann Selection – Tournament selection – Rank Selection – Steady – State Selection – Elitism – Generation gap and steady state replacement – Inheritance operators – Cross Over-Inversion and deletion – Mutation operator – Bit – wise operators – Generational Cycle – convergence of Genetic Algorithm – Differences and Similarities between GA and other traditional methods – Applications.

References:

1. S. N. Sivanandam, S. N. Deepa, Principles of Soft Computing, Wiley India Pvt. Ltd [Module I&III].
2. R. Rajasekharan and G.A. Vijayalakshmi Pai, Nerural Networks, Fuzzy Logic and Genetic algorithms-Synthesis and Applications, Prentice Hall of India. [Module II&IV]
3. Fakhreddine O. Karray, Clarence De Silva, Intelligent Systems Design, Theory, Tools and Application, Pearson Education.
4. S. Haykins, Neural Networks – A Comprehensive foundation, Prentice Hall 2002.
5. L. Fausett, Fundamentals of Neural Networks, Prentice Hall 1994.
6. T. Ross, Fuzzy Logic with Engineering Applications, Tata McGraw Hill, New Delhi 1995.
7. D. E. Goldberg, Genetic Algorithms in search, Optimization and machine Learning, Addison Wesley M A, 1989.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 105 (C) AERODYNAMICS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To impart basic knowledge in aerodynamics*

Module I (13hrs)

Equations for incompressible inviscid flows, Fluid circulation and rotation, Vorticity, Kelvin's theorem, Velocity potential, Stream function, Equation of a stream line, Complex potential, Elementary flow patterns and their superposition.

Module II (13 hours)

Flow past a cylinder, Magnus effect, Kutta condition, Vortex theory of lift, Conformal transformation, TheJowkowski transformation, Lift on arbitrary cylinder, Aerodynamic center, Pitching moment.

Module III (13 hours)

Aerofoils, Low speed flows over aerofoils-the vortex sheet, Thin aerofoil theory, Symmetric aerofoil, Tear drop theory, Camber line at zero angle of attack, Characteristics of thin aero foils, Motion in three dimensions, Flow ast slender bodies.

Module IV (13 hours)

Finite wings, Downwash and induced drag, Prandtl-Lachester theory, Biot- Savarat law, General series solution, Glauret method, Multhop's method, Horseshoe effects, Ground effects, Lineraised compressible flows in two dimensions, Flow past a wavy wall, Similarity rules, Aerofoil in compressible flows.

References

1. Kuethe, A. M. and Chow, C., Foundations of Aerodynamics, Fourth Edition, Wiley Eastern, 1986.
2. Katz, J. and Plotkin, A., Low Speed Aerodynamics, McGraw-Hill, 1991.
3. Milne-Thomson, L. M., Theoretical Hydrodynamics, Macmillan, 1958
4. Anderson Jr., J. D., Fundamentals of Aerodynamics, McGraw Hill, 1988.
5. Houghton, E. L. and Brock, A. E., Aerodynamics for Engineering Students, Second Edition, Edward Arnold, 1970.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 105 (D) MAINTENANCE ENGINEERING AND MANAGEMENT

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To impart knowledge on maintenance management, diagnostic maintenance and non-destructive testing*

Module I (13hrs)

Maintenance Management – Maintenance strategies, breakdown, preventive and predictive maintenance, TPM, RCM, Spare parts management, Economic Aspects – Life cycle costing, maintenance cost, Organizational structure for maintenance, Reliability, Availability and Maintainability

Module II (13 hours)

Tribology in Maintenance – Friction and wear mechanisms – Lubrication mechanisms – Lubrication processes – Lubricants – additives, degradation and testing

Condition based maintenance - Performance trend monitoring, Condition monitoring, Lubricant monitoring – spectrometric oil analysis procedure, ferrography

Module III (13 hours)

Vibration monitoring – Data acquisition, Transducers, Time domain and frequency domain analysis, Phase signal analysis, Fault diagnosis of rotating equipments, antifriction bearings and gears

Module IV (13 hours)

Non-destructive testing – Visual examination – optical aids, liquid penetrant testing, magnetic particle testing, eddy current testing, radiography, ultrasonic testing, acoustic emission testing, thermography, leak testing, corrosion monitoring, standards for NDT.

References

1. Mishra, R. C. and Pathak, K., Maintenance Engineering and Management, Second Edition, Prentice Hall of India, New Delhi, 2004.
2. Dhillon B.S., Engineering Maintenance: A Modern Approach, Taylor & Francis Group, 2002.
3. Mobley R. K., An Introduction to Predictive Maintenance, Second Edition, Butterworth-Heinemann, 2002
4. Scheffer C. and Girdhar P., Machinery Vibration Analysis & Predictive Maintenance, IDC Technologies, 2004.
5. Taylor J. L., The Vibration Analysis Handbook, Vibration Consultants, 2003.
6. Baldev Raj, Jayakumar T. and Thavasimuthu M., Practical Non-destructive Testing, Narosa, 2002.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 105 (E) RESEARCH METHODOLOGY

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: - *Generating a good understanding of research methodology*

Module 1 (13 Hours)

Research: Meaning – purpose - types of research - identification, selection and formulation of research problem - research questions - research design - formulation of hypothesis - review of literature. Data for research: Primary and secondary data - collection methods – processing data Basic statistical measures: Measures of central tendency and variation - skewness and kurtosis.

Module 2(13 hours)

Measures of relationship: Correlation – correlation coefficient for ungrouped data and grouped data – rank correlation – auto correlation, linear regression - simple regression and multiple regression.
Probability: Definition – discrete and continuous probability distributions: binomial, poison, uniform, exponential and normal distributions.
Sampling technique: Sampling theory – sampling methods – sampling distributions – confidence interval estimation - sample size – advantages and limitations of sampling.

Module 3 (13 Hours)

Hypothesis testing and estimation: Fundamentals of hypothesis testing - testing of significance mean, proportion, variance and correlation – goodness of fit test.
Non - parametric tests: Sign test, Kolmogorov-Smirnov test – Mann-Whitney test - Kruskal- Wallis test.

Module 4 (13 Hours)

Design of experiments: Analysis of variance (ANOVA) - completely randomized design - randomized complete block design - latin square designs, Factorial design - 2^n factorial design – 2^2 and 2^3 factorial design - Yates' algorithm for 2_n factorial experiment.

References:

1. Panneerselvam, R., "Research methodology", Prentice Hall of India Private Limited, New Delhi, 2006
2. Kothary, C. R., "Research methodology: methods and techniques", New Age International, New Delhi, 2008
3. Goddard, W. and Melville, S., "Research methodology – an introduction", Juta & Co. Ltd., Lansdowne, 2007

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks
Question pattern:
Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 106 (P): *THERMAL SYSTEMS LAB/MINI PROJECT*

Teaching scheme: 2 hours practical per week **Credits:** 2

Objectives

- *To acquaint with heat transfer and thermal systems and their basic principles.*
- *To acquire knowledge on various advanced heat transfer equipments*
- *To gather knowledge regarding IC engines and refrigeration systems.*

Internal Continuous Assessment *(Maximum Marks-100)*

Regularity	30%
Record	20%
Test/s, Viva-voce	50%

MEA10 107 (P): SEMINAR

Teaching scheme: 2 hours per week **Credits:** 2

Objective: *To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his ideas and thus creating in him self esteem and courage that are essential for an engineer.*

- Individual students are required to choose a topic of their interest from energy related engineering topics preferably from outside the M.Tech syllabus and give a seminar on that topic about 30 minutes. A committee consisting of at least three faculty members (preferably specialized in Mechanical engineering) shall assess the presentation of the seminar and award marks to the students. Each student shall submit two copies of a write up of his / her seminar topic. One copy shall be returned to the student after duly certifying it by the Chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

- **Internal continuous assessment: 100 marks**

  Evaluation shall be based on the following pattern:

Report	=	50 marks
Concept/knowledge in the topic	=	20 marks
Presentation	=	30 marks
Total marks	=	100 marks

MEA10 201 DESIGN OF EQUIPMENTS FOR ENERGY CONVERSION SYSTEMS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives

- *To provide a basic knowledge for designing equipment related energy conversion systems.*

Module 1 (13 hours)

Factors influencing the design of pressure vessels, design criterion of elliptical, hemispherical, conical, toriconical and torispherical heads, Stresses in pressure vessels, Autofrettage, Thermal stresses, Design of pressure vessel components such as shell, heads, Nozzles, Flanges as per ASME & IS codes.

Module II (13 Hours)

Design of vessels - Buckling -Buckling phenomenon – Elastic buckling of circular ring and cylinders under external pressure –Stiffeners. Piping- - Flexibility analysis- Design as per ANSI Codes.

Module III (13 hours)

Heat exchangers - classification – selection – heat transfer and flow friction characteristics – pressure drop analysis – basic thermal design – theory of heat exchangers – E-NTU, P-NTU and MTD method - F-factor for various configurations - applications to design. Shell and tube heat exchanger – construction and thermal features – thermal design procedure – Kern method – Bell Delaware method.

Module IV (13 hours)

Thermal design of regenerators – classifications – governing equations – design parameters. Design of compact heat exchangers – plate and fin, fin-tube and plate and frame heat exchangers – fouling and corrosion in heat exchanger.

References

1. J. F. Harvey, *Theory and Design of Pressure Vessels*, CBS Publishers and Distributors, 1987.
2. Henry H. Bedner, *Pressure Vessels, Design Hand Book* , CBS Publishers and Distributors, 1987.
3. Stanley, M. Wales, *Chemical Process Equipment, Selection and Design*, Buterworths series in Chemical Engineering, 1988.
4. ASME Pressure Vessel Codes Section VIII, 1998.
5. Dennis Moss Pressure vessel design manual Gulf publishing, 2003
6. Brownell, L. E., and Young, E. H., Process Equipment Design, John Wiley and Sons
7. Kern, D. Q., Process Heat Transfer, Tata McGraw-Hill, 2000.
8. Fraas, A. P., Heat Exchanger Design, Second Edition, John Wiley & Sons, 1989
9. Hewitt , Process heat transfer
10. Das, S.K., Prosess heat transfer, Narosa publishing house.2005.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 202 : MATERIALS SCIENCE AND TRIBOLOGY FOR ENERGY CONVERSION SYSTEMS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives:

To understand the principles of behavior of ductile and brittle materials and lubrication systems

Module I (13 hours)

Elastic behaviour of materials and composites, plastic deformation, slip systems in crystals, strengthening, ductile and brittle fracture, Griffith Criterion, Creep and Fatigue. Factors influencing functional life of components at elevated temperatures, definition of creep curve, various stages of creep, metallurgical factors influencing various stages, effect of stress, temperature and strain rate. Design of transient creep time, hardening, strain hardening, expressions of rupture life of creep in ductile and brittle materials, Monkman-Grant relationship.

Module II (13 hours)

Corrosion: Corrosion theory and mechanisms, in depth corrosion chemistry for boilers, pipelines, cooling towers and pressure vessels, Oxidation, Pitting, Bedworth ratio, kinetic laws of oxidation- defect structure and control of oxidation by alloy additions, hot gas corrosion deposit, modified hot gas corrosion, fluxing mechanisms, effect of alloying elements on hot corrosion, interaction of hot corrosion and creep, methods to combat hot corrosion.

Module III (13 hours)

Engine Lubrication System and their components, bearing lubrication, lubrication of piston, ring and liners, function of engine lubrication, fundamental of lubrication, regimes of lubrication-hydrodynamic, mixed and boundary lubrication, elasto- hydrodynamic lubrication, description of engine components working of each of these regimes . Lubricants – Selection criteria.

Module IV(13 hours)

Surfaces features – Topography- Experimental Determinations of surface structure – Chemical analysis of surface – Surface effects in Tribology –Friction – Mechanism of friction, measuring friction, Properties of metallic and non metalli c materials- friction in extreme conditions - Wear – Types, mechanism, mapping, measurements, wear resistance materials – surface treatment, surface modifications and surface coatings

References:

1. Raj. R., “Flow and Fracture at Elevated Temperatures, American Society for Metals, USA, 1985.
2. Hertzberg R. W., “Deformation and Fracture Mechanics of Engineering materials, 4th Edition, John Wiley, USA, 1996.
3. Courtney T.H, “Mechanical Behavior of Materials, McGraw-Hill, USA, 1990.
4. Halling, J.(Editor) – “ Principles of Tribology”, MacMillan, 1984.
5. Williams, J.A. “Engineering Tribology”, Oxford University Press, 1994.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 203 ADVANCED INSTRUMENTATION SYSTEMS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To understand the basic principle and working of various measuring devices*

Module 1 (13 hours)

Dynamic characteristics - zero, first and second order instruments - step, ramp, frequency and impulse responseData acquisition - analog and digital conversion – post processing of data - statistical analysis - goodness of data - correlating data - linear and non-linear regression. Measurements of viscosity - use of poiseuille flow, falling, rotating and oscillating bodies, Thermal conductivity of solids and liquids - Measurement of specific heat of gases

Module II (13 hours)

Temperature measurement - scales - thermocouple, resistance and magnetic thermometry.
Error estimates in temperature measurements - solids and fluids - steady state and unsteady measurements - radiation effects - platinum resistance thermometers - construction and usage - calibration - bridges
Fluid pressure measurement – high pressure and low pressure - capacitive probes - piezoelectric pressure sensors – velocity and discharge measurements

Module III (13 hours)

Thermal radiation measurements - radiometry - surface radiation measurements – gas radiation instruments - errors in radiation measurements - transient experimental techniques for surface heat flux rates – negligible internal resistance - negligible surface resistance - rapid response measurements - thick film and thin film gauges – non uniform surface temperatures - quasi steady measurements.

Module IV (13 hours)

Temperature measurements in high temperature gases - calorimetric, electrostatic, radiation, pressure and heat flux probes - cooled film sensors - optical measurements – Schlieren shadow - graph and interferometer - errors in optical measurements.Light intensity and Electrical power measurement

References

1. E.R.G. Eckert and R.J. Goldstein: Measurements in Heat Transfer, McGraw Hill, 1976
2. J.P. Holman: Experimental Methods for engineers, McGraw Hill, 2
3. E.O. Doebelin: Measurements Systems: Application and Design, McGraw Hill, 2010
4. T.G. Beekwith R.D. Marangoni and J.H. Lienhard: Mechanical measurements, Pearson Education, 2001
5. Barney: Intelligent Instrumentation, Printice Hall, 1988
6. S.P. Venkatesan: Mechanical measurements, Ann publications, 2008

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:
Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 204 (A) HYDROPOWER SYSTEMS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives:- *To provide knowledge on hydropower systems*

Module 1 (13 hours)

Principles of modeling and similitude as applied to Turbo-machines-Euler's turbine equation – Analysis of turbines – constructional features of Pelton, Francis and Kaplan turbines. Development of prototype systems. Power station operation and maintenance. Load control and controlling power distribution Reservoirs. Importance of Mini and micro-hydro power systems.

Module 2 (13 hours)

Overview of Hydropower systems - Case studies- Preliminary Investigation –Determination of Requirements – preparation of Reports and Estimates –Review of World resources – Cost of Hydroelectric Power-Basic Economic Factors.

Module 3 (13 hours)

Analysis of Hydropower projects – Project Feasibility – Load Prediction and Planned Development – Advances in Planning, Design and Construction of Hydroelectric Power Stations – Trends in Development of Generating Plant and Machinery –Plant Equipment for pumped Storage Schemes – Some aspects of Management and Operations – Updating and Refurbishing of Turbines.

Module 4 (13 hours)

Governing of Power Turbines-Functions of Turbine Governor-Condition for Governor Stability-Surge Tank Oscillation and Speed Regulative Problem of Turbine Governing in Future Problem of management – Maintenance of civil Engineering works-Maintenance of Electrical Engineering works Computer aided Hydropower System analysis -Design-Execution-Testing-Operation and control of Monitoring of Hydropower Services.

References:

1. Principles of Turbo machinery, Shephered D.G., Macmillan Company, Newyork
2. Hydraulic Turbines, Krevichenko, MIR Publishers.
3. Micro Hydro Electric Power Station (1984), L. Monition, M. Lenir and J Roux.
4. Micro Hydro Power Source book (1986), Alen R. Inversin.
5. Power Plant Evaluation and design (1988) Tyler G. Hicks.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 204(B) ADVANCED THERMODYNAMICS AND COMBUSTION

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To understand the principles of combustion and to get broad knowledge in thermodynamics.*

Module 1 (13 hours)

Thermodynamics-equation of state, properties of gas mixtures, First law of thermodynamics, enthalpy of formation and heat of reaction, stoichometric and equivalence ratio, adiabatic flame temperature.

Module 1I (13 hours)

Second law of thermodynamics and concept of chemical equilibrium, Gibbs free energy and the equilibrium constant of a chemical reaction (Vant Hofts equation). Calculation of equilibrium composition of a chemical reaction.

Module III (13 hours)

Fuels and their properties- Review of basic thermodynamics and gaseous mixtures. Combustion Thermodynamics; Stoichiometry; the First and Second Laws of Thermodynamics applied to combustion; Composition products in equilibrium;

Module IV (13 hours)

Fundamentals of combustion kinetics- General characteristics of combustion flame and detonation- Laminar flame propagation- Flammability limits and quenching of laminar flames- Ignition, Turbulent flame propagation- Flame stabilization, Gas jets and combustion of gaseous fuel jets. Vaporization and Combustion of liquid fuel droplet. Combustion of a coal particle.

References:

1. Kuo, K.K., Principles of combustion, Wiley Inter science , New york,1986.
2. Murthy,K.A., Introduction to combustion, Golden and Breach, New York, 1975.
3. Sharma, S.P and Chandra Mohan, Fuels and combustion, McGraw Hill, 1984.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:
Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 204 (C) OPTIMISATION TECHNIQUES

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits: 4**

Objectives: *To impart knowledge on various aspects of optimization techniques*

Module 1 (13 hours)

Mathematical preliminaries: Mathematical programming problems-varieties and characteristics-Examples of problem formulation- difficulties caused by non- linearity-Convex sets-convex functions- concave functions-convex feasible region optimal solution-Quasi- convexity – unimodal function- Differentional functions-gradient and Hessian- properties of convex functions.

Module II (13 hours)

Unrestricted and classical optimization: search methods- Fibonacci search- Golden section search- Quadratic interpolation method- pattern search method-steepest descent method-Quasi Newton method- Hooke and Jeeves method-Lagrangier Multiplier method-Sufficiency condition- calculus of variations- Euler's equation-Necessary codition-transversality condition-problems with constraints

Module III (13 hours)

Constrained non-linear optimization: problems involving inequality constrainta-Kuhn-Tucker conditions-Quadratic programming – Wolfe's method- method of feasible directions-Frank and Wolf method- Convex simplex method- separable programming-Kelly's cutting plane method-Penalty and Barier methods

Module IV (13 hours)

Integer and dynamic programming, Optimization methods applied to unconstrained and constrained linear and non-linear functions of one or more variables. Introduction to response surface methods and genetic algorithms. Non-linear function approximation using neural networks in optimization. Biological methods in optimization.

References

1. Kambo,N.S, Mathematical programming techniques, Affiliated East West, 1984.
2. Intriligantor,M.D., Mathematical Optimization and Economic theory, Prentice Hall,1971.
3. Rao,S.S., Optimization theory and applications ,Wiley Eastern 1978.
4. Summons,D.L., Non-linear programming for operations research, prentice hall 1975.
5. Ranjan Ganguli., Engineering Optimization – A Modern Approach, Universities Press, Hyderabad, 2011.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	**Module II**	**Module III**	**Module IV**
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 204 (D) CRYOGENICS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits: 4**

Objectives: - *Generating a good understanding of various cryogenic systems*

Module 1 (13 hours)

Gas liquefaction systems, thermodynamically ideal systems, Joule Thomson effect, adiabatic expansion; liquefaction system for air, Neon, hydrogen and helium, effect of component efficiencies on system performance.

Module II (13 hours)

Gas separation and purification – principles, plant calculation, air, hydrogen, and helium separation systems.

Module 1II (13 hours)

Cryogenic refrigeration systems, ideal and practical systems, cryogenic temperature measurement; cryogenic fluid storage and transfer systems, storage vessels and insulation, two-phase flow in cryogenics transfer systems, cool down process.

Module 1V (13 hours)

Introduction to vacuum technology, low temperature properties of materials, pump down time, application ofcryogenic systems, super-conductive devices, rocket and space simulation, cryogenics in biology and medicine, cryopumping.

References

1. Barron, R., Cryogenic Systems, McGraw-Hill, 1966.
2. Timmerhaus, K. D. and Flynn, T. M., Cryogenic Process Engineering, Plenum Press, 1989.
3. Scott, R. B., Cryogenic Engineering, D'Van-Nostrand, 1962.
4. Vance, R. W. and Duke, W. M., Applied Cryogenic Engineering, John Wiley, 1962.
5. Sitting, M., Cryogenics, D' Van-Nostrand, 1963

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 204 (E) REFRIGERATION ENGINEERING

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits: 4**

Objectives: - *Generating a good understanding of various refrigeration systems*

Module I (13 hours)

Introduction to refrigeration systems, Review of basics - methods of refrigeration, units of refrigeration, COP.
Vapour compression refrigeration system, vapour absorption system.
Magnetic refrigeration, pulse tube refrigeration, acoustic refrigeration, Thermo electric refrigeration, vortex tube refrigeration -details and applications.

Module II (13 hours)

Advanced vapour compression systems – compound compression, multi stage evaporation.
Vapour Absorption system – Description – analysis – applications.
Solar based refrigeration technologies – absorption and adsorption type systems.

Module III (13 hours)

Introduction to Magnetic refrigeration - magneto-caloric effect, magnetic materials, advantages over traditional refrigeration system.
Principles and application of steam jet refrigeration system – performance analysis

Module IV (13 hours)

Conventional and alternative refrigerants – Refrigerant Designation-Need for alternative refrigerants – environmental issues – mixture refrigerants – modifications required for retrofitting, safety precautions and compatibility of refrigerants.

References:

1. Arora C. P, Refrigeration and Air conditioning-Tata Mc Graw Hill, 2004
2. Arora, Refrigeration and Air-conditioning, PHI, Eastern Economy Edition, 2012
3. Gosney W. B, Principles of Refrigeration, Cambridge University Press, 1983
4. Stanley W Angrist, Direct Energy conversions, Allyn & Bacon, 1982
5. HJ Goldsmid, Thermoelectric Refrigeration, Springer, 1st Ed. 1995

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 205(A) SOLAR ENGINEERING

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives:

To understand the basics of solar engineering, its collection and its applications.

Module I (13 hours)

Sun and it's Energy: Solar spectrum, solar constant & solar radiations, Sun earth angles, solar hourly radiations - Radiations on Horizontal and inclined surfaces. Measurement of Solar Radiation: Pyrheliometer, Pyranometer, Sunshine-Recorder.

Module II (13 hours)

Collection of Solar Energy : Flat plate collectors, classification, construction, heat transfer coefficients, optimisation of heat losses - Analysis of flat plate collectors, testing of collectors-Solar Air Heater : Description & classification, conventional air heater, air heater above the collector surface air heaters with flow on both sides of absorbers to pan air heater, air heater with finned absorbers, porous absorber.

Module III (13 hours)

Solar Water heater: Collection cum storage water heater, Natural circulation & forced circulation water heater, shallow solar ponds. Solar Concentrators: Classification, characteristic parameters, types of concentrators materials in concentrators.

Module IV (13 hours)

Passive Solar House: Thermal gain, Thermal cooling, Ventilation. Energy Storage: Sensible heat storage, Liquid, Solid, packed bed, Latent heat storage. Solar Distillation, Solar Cookers, Solar Refrigeration.

References:

1. Tiwari, G.N. and Sayesta Suneja., Solar Thermal engineering Systems, Narosa Publishing House.
2. H.P. Gupta.,Solar Engineering
3. Duffie and Backuran, Solar Thermal Engineering.
4. Sukhatme, Solar Engineering.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 205 (B) RENEWABLE ENERGY SYSTEMS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives:

To understand the principles of renewable energy systems.

Module 1 (13 hours)

World energy use – Reserves of energy resources – Environmental aspects of energy utilisation – Renewable energy scenario in India – Potentials – Achievements – Applications.

Module 1I (13 hours)

Solar thermal – Flat plate and concentrating collectors – Solar heating and cooling techniques – Solar desalination – Solar Pond – Solar cooker – Solar thermal power plant – Solar photo voltaic conversion – Solar cells – PV applications.

Module III (13 hours)

Wind data and energy estimation – Types of wind energy systems – Performance – Details of wind turbine generator – Safety and Environmental Aspects.

Biomass direct combustion – Biomass gasifier – Biogas plant – Ethanol production – Bio diesel – Cogeneration – Biomass applications.

Module 1V (13 hours)

Tidal energy – Wave energy – Open and closed OTEC Cycles – Mini and Micro hydro – Geothermal energy – Fuel cell systems.

References:

1. G.D Rai : Non conventional Energy Sources. Khanna Publishers, New Delhi
2. S.P Sukhatme : Solar Energy. Tata McGraw Hill Publishing company Ltd, New Delhi
3. Godfrey Boyle : Renewable energy, Power for a sustainable future. Oxford University press U.K
4. Twidell J W & Weir A : Renewable energy sources. EFN spon Ltd U.K
5. G N Tiwary : Solar Energy-Fundamental Design, modelling and application. Narosa Publishing house, New Delhi
6. L L Freris : Wind energy conversion system. Prentice Hall U K

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 205 (C) NUCLEAR ENGINEERING

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To provide knowledge on various aspects of nuclear engineering*

Module I (13 hours)

Nuclear model of the atom - Equivalence of mass and energy - Binding - Radio activity
Half life –Neutron interactions - Cross sections

Module II (13 hours)

Mechanism of nuclear fission and fusion - Radio activity - Chain reactions - Critical mass and composition - Nuclear fuel cycles and its characteristics - Uranium production and purification - Zirconium, thorium, beryllium

Module III (13 hours)

Nuclear fuel cycles - spent fuel characteristics - Role of solvent extraction in reprocessing - Solvent extraction equipment. Reactors - Types of reactors - Design and construction of fast breeding reactors - heat transfer techniques in nuclear reactors - reactor shielding.

Module IV (13 hours)

Nuclear plant safety- Safety systems - Changes and consequences of an accident - Criteria for safety - Nuclear waste - Type of waste and its disposal - Radiation hazards and their prevention - Weapons proliferation.

References:

1. Thomas J. Cannoly, "Fundamentals of Nuclear Engineering ", John Wiley (1978).
2. Collier J.G., and G.F.Hewitt, "Introduction to Nuclear Power ", (1987), Hemisphere Publishing, New York.
3. Lamarsh U.R. " Introduction to Nuclear Engineering Second Edition ", (1983), Addison Wesley M.A.
4. Lipschutz R.D. " Radioactive Waste - Politics, Technology and Risk ", (1980), Ballingor, Cambridge. M.A.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:
Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 205 (D) INDUSTRIAL NOISE CONTROL

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: - *To understand various aspects of industrial noise control*

Module 1 (13 hours)

Sound wave characteristics - Sound levels and decibels - adding, subtracting, averaging - directivity- directivity factor- directivity index.

Module 1I (13 hours)

The human ear- frequency and loudness response - heating loss - psychological response to noise - noise criteria curves - noise control criteria and regulations - major source of noise – instrumentation - indoor measurement - outdoor measurement – microphones -sound level meters - spectrum analyzers - environmental noise measurements.

Module 1II (13 hours)

Sources of noise – fan or blower noise- electric motors- pumps- air compressor noise- building and construction equipment noise- home appliances noise- room acoustics- acoustics of walls- enclosures and barriers – transmission loss- and transmission coefficients- acoustical materials and structures.

Module 1V (13hours)

Vibration control systems for industrial applications- vibration systems- vibration control-vibration measurement-machine protection and malfunction diagnosis-causes of vibrations-rotor dynamics-instrumentation-diagnostic analysis.

References:

1. Irwin, J.D. and Graf E.R., Industrial noise and vibrations control. Prentice Hall, INC.
2. Munjal, M.L., Acoustics of Ducts and Mufflers, Wiley Interscience NY1987
3. Bies, D.A and C H Hanson, Engineering Noise control, Spon Pras, London 2003

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 205 (E) NANO SCIENCE AND TECHNOLOGY

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To understand the concept of nanotechnology, nanomaterials, charecterization of nano particles and emerging application of nanomaterials.*

Module I (13 hours)

Introduction - What is nano? Why nano? Nanomaterials -Solid state Physics: Crystal structure - crystal diffraction and reciprocal lattice, point groups and space groups.

Module II (13 hours)

Types of bonding-elementary ideas about point defects and dislocations- lattice vibrations- phonons- specific heat of solids- free electron theory-Fermi statistics- heat capacity.

Module III (13 hours)

Nanomaterials-Fabrication and characterization: Bottom-up vs. top-down, Epitaxial growth, principles of Self-assembly, Characterization : XRD, TEM, SEM, STM, AFM , XPS.

Module IV (13 hours)

Electronic Nanodevices- Magnetic Nanodevices -Photonic Nanodevices,-Semiconductor quantum dots- Photonic crystals -Metamaterials- Societal, Health and Environmental Impacts .

References:

1. Kulkarni, S.K., Nanotechnology: Principles and Practices, Capital Publishing Co., 2007.
2. Kelsall, R., Hamley, I., and Geoghegan, M. (Eds), Nanoscale Science and Technology, Wiley, 2005.
3. Hummel, R.E., Electronic Properties of Materials, Third Edn, Springer, 2001.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:
Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA 10 206 (P): SEMINAR

Teaching scheme: 2 hours per week **Credits:** 2

Objectives: *To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his ideas and thus creating in him / herself esteem and courage that are essential for an engineer.*

- Individual students are required to choose a topic of their interest from energy related topics preferably from outside the M.Tech syllabus and give a seminar on that topic about 30 minutes. A committee consisting of at least three faculty members (preferably specialized in Mechanical engineering) shall assess the presentation of the seminar and award marks to the students. Each student shall submit two copies of a write up of his / her seminar topic. One copy shall be returned to the student after duly certifying it by the Chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

- **Internal continuous assessment: 100 marks**

  Evaluation shall be based on the following pattern:

Report	=	50 marks
Concept/knowledge in the topic	=	20 marks
Presentation	=	30 marks
Total marks	=	100 marks

MEA10 207 (P): MECHANICAL ENGINEERING DESIGN LAB/MINI PROJECT

Teaching scheme: 2 hours per week **Credits:** 2

Objectives:

- *To impart knowledge regarding various design and analysis softwares*
- *To practice the steps involved for the selection, execution, and reporting of the project.*
- *To train the students for group activities to accomplish an engineering task.*

For Mini Project, individual students are required to choose a topic of their interest. The subject content of the mini project shall be from emerging / thrust areas, topics of current relevance having research aspects or shall be based on industrial visits. At the end of the semester, the students should submit a report duly authenticated by the respective guide, to the head of the department.

Internal Continuous Assessment *(Maximum Marks-100)*

Regularity	30%
Record / Report	20%
Test/s, Viva-voce	50%

Semester End examination will be conducted by a committee consisting of three faculty members. The students are required to bring the report completed in all respects duly authenticated by the respective guide and head of the department, before the committee. Students individually will present their work before the committee. The committee will evaluate the students individually and marks shall be awarded as follows.

- Record/Report = 25 marks
- Concept/knowledge in the topic = 15 marks
- Presentation = 10 marks

Total marks = 50 marks

MEA10 301 (A) MANUFACTURING METHODS FOR ENERGY CONVERSION SYSTEMS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: - *To provide basic knowledge for manufacturing methods related to energy conversion systems*

Module I (13 hours)

Selection of materials for high/low temperature applications – superconductive materials - composites for high/low temperature applications – nanomaterials interface for high/low temperature applications – structural considerations

Module II (13 hours)

Materials used for manufacturing of water turbine components - Factors influencing their selection. Yield and fatigue strength considerations-resistance to corrosion - oxidation and erosion due to caviation etc.

Module III (13 hours)

Processes for manufacture of hydraulic/turbo machinery elements – types of turbine blades, shafts, yoke etc. Casting methods - Pressure moulding, investment moulding applicable to critical components - Heat treatment for strength considerations- failure aspects – testing practices.

Module IV (13 hours)

Manufacturing practices for critical components susceptible to enormous heat gradient – endurance limit applicable to drastic fluctuation of heat – additional requirements for design and manufacture of heat exchangers, heat pipes and cryo cooler components – case studies-Solar cell manufacturing processes: material resources, chemistry, and environmental impacts; low cost manufacturing processes.

References

1. Advanced Materials and Systems for Energy Conversion: Fundamentals and Applications (Energy Science, Engineering and Technology) [Hardcover], Yong X. Gan (Editor), Nova Science Pub Inc (July 2010), ISBN-10: 1608763498, ISBN-13: 978-1608763498

2. Bottom of Form G. Luna-Sandoval, G. Urriolagoitia-C, L.H. Hernández, G. Urriolagoitia-S, E. Jiménez, Hydrogen Fuel Cell Design and Manufacturing Process Used for Public Transportation in Mexico City, Proceedings of the World Congress on Engineering 2011 Vol III, WCE 2011, July 6 - 8, 2011, London, U.K., ISBN: 978-988-19251-5-2 ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online).

3. Klaus Steffens, Hans Wilhelm, Next Engine Generation: Materials, Surface Technology, Manaufacturing Processes, What comes after 2000? MTU AeroEngines, http://www.mtu.de/en/technologies/engineering_news/production/Steffens_Next_engine_generation.pdf

4. K. Liu, E. Ferraris, J. Peirs, B. Lauwers, D. Reynaerts, Precision manufacturing of the ultra-miniature gas turbine in ceramic composite for the micro power generation system Proceedings of the euspen International Conference – Zurich - May 2008. https://lirias.kuleuven.be/bitstream/123456789/198299/1/08PP131.pdf

5. David Drechsler, Modern Trends In Gas Turbine Engine Component Manufacture, http://www.huffmancorp.com/news_and_events/articles/gas_turbine_trends.html

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 301(B) ENERGY POLICIES FOR SUSTAINABLE DEVELOPMENT

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To understand the social and economic aspects of energy management and its influence on planning*

Module I (13 hours)

Energy policies of India – Supply focus approach and its limitations – Energy paradigms – DEFENDUS approach – End use orientation – Energy policies and development – Case studies on the effect of Central and State policies on the consumption and wastage of energy – Critical analysis – Need for renewable energy policies in India.

Module II (13 hours)

Energy and environment – Green house effect – Global warming – Global scenario – Indian environmental degradation – environmental laws – Water (prevention & control of pollution) act 1974 – The environmental protection act 1986 – Effluent standards and ambient air quality standards – Latest development in climate change policies & CDM.

Module III (13 hours)

Energy conservation schemes – Statutory requirements of energy audit – Economic aspects of energy audit – Capital investments in energy saving equipment – Tax rebates – Advantages of 100% depreciation – India's Plan for a domestic energy cap & trade scheme.

Module IV (13 hours)

Social cost benefit analysis – Computation of IRR and ERR – Advance models in energy planning – Dynamic programming models in integrated energy planning – Energy planning case studies – Development of energy management systems – Decision support systems for energy planning and energy policy simulation.

References:

1. J. Goldemberg, T.B. Johansson, A.K.N. Reddy and R.H. Williams: Energy for a Sustainable World, Wiley Eastern, 1990.
2. IEEE Bronze Book: Energy Auditing, IEEE Publications, 1996.
3. P. Chandra: Financial Management Theory and Practice, Tata McGraw Hill, 1992.
4. Annual Energy Planning Reports of CMIE, Govt. of India.
5. Amlan Chakrabarti: Energy Engineering and Management, PHI, Eastern Economy Edition, 2012
6. A.K.N. Reddy and A.S. Bhalla: The Technological Transformation of Rural India, UN Publications, 1997.
7. A.K.N. Reddy, R.H. Williams and J.B. Johanson: Energy After Rio-Prospects and Challenges, UN publications, 1997.
8. P. Meier and M. Munasinghe: Energy Policy Analysis & Modeling, Cambridge University Press, 1993.
9. R.S. Pindyck and D. L. Rubinfeld: Economic Models and Energy Forecasts, 4e, McGraw Hill, 1998.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 301(C) ENERGY EFFICIENT BUILDINGS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To understand the concept of energy conscious building design.*

Module I (13 hours)

Climate and shelter – Historic buildings – Modern architecture – Examples from different climate zones – Thermal comfort – Solar geometry and shading – Heating and cooling loads – Energy estimates and site planning – Integrative Modelling methods and building simulation..

Module II (13 hours)

Principles of Energy conscious building design – Energy conservation in buildings – Day lighting – Water heating and photovoltaic systems – Advances in thermal insulation – Heat gain/loss through building components – Solar architecture.

Module III (13 hours)

Passive solar heating – Direct gain – Thermal storage wall – Sunspace – Convective air loop – Passive cooling – Ventilation – Radiation – Evaporation and Dehumidification – Mass effect – Design guidelines.

Module IV (13 hours)

Energy conservation in building – Air conditioning – HVAC equipments – Computer packages for thermal design of buildings and performance prediction – Monitoring and instrumentation of passive buildings – Control systems for energy efficient buildings – Illustrative passive buildings – Integration of emerging technologies – Intelligent building design principles.

References:

1. J.A. Clarke, Energy Simulation in Building Design (2e) Butterworth 2001.
2. J.K. Nayak and J.A. Prajapati Hadbook on Energy Consious Buildings, Solar Energy Control MNES, 2006.
3. Energy Conservation Building Codes 2006; Bereau of Energy Efficiency.
4. J.R. Williams, Passive Solar Heating, Ann Arbar Science, 1983.
5. R.W. Jones, J.D. Balcomb, C.E. Kosiewiez, G.S. Lazarus, R.D. McFarland and W.O. Wray, Passive Solar Design Hanbook, Vol.3, Report of U.S. Department of Energy (DOE/CS-0127/3), 1982.
6. M.S. Sodha, N.K., Bansal, P.K. Bansal, A.Kumar and M.A.S. Malik. Solar Passive Building, Science and Design, Pergamon Press, 1986.
7. J.L. Threlkeld, Thermal Environmental Engineering, Prentice Hall, 1970.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 301 (D) RELIABILITY ENGINEERING

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To understand the basic principles of reliability engineering and its applications to various systems in engineering*

Module 1 (13 hours)

Probability: Conditional probability, Baye's theorem, Probability distributions – Normal, Lognormal, Poisson, Exponential and Weibull distributions – relationship between them and their significance - central tendency and dispersion, point estimation and interval estimation, goodness of fit tests

Reliability: Definitions, Importance, Quality and reliability, bath tub curve -Failure data analysis: Hazard rate, failure rate, MTTF, MTBF, reliability functions, hazard functions, Availability and Maintainability

Module II (13 hours)

Reliability hazard models: Parts stress model, Constant, linearly increasing and time dependent failure rates, Weibull model, distribution functions and reliability analysis

System Reliability: System configurations, series, parallel, mixed configurations, k out of m system, standby systems

Module III (13 hours)

Reliability evaluation using Markov model

Development of logic diagram, set theory, optimal cut set and tie set methods, Markov analysis

Fault tree analysis and event tree analysis - Failure Modes and Effects Analysis (FMEA), Failure Modes, Effects and Criticality Analysis (FMECA)

Module IV (13 hours)

Interference theory and reliability computations – Normal, exponential and Weibull stress - strength distributions

Life Testing – Objectives, Types - Censoring, replacement, accelerated life testing – data quantification – Temperature stress and failure rates – stress combinations.

References

1. Naikan A., Reliability Engineering and Life Testing, PHI, New Delhi, 2010
2. O'Connor PDT, Practical Reliability Engineering, John Wiley & Sons Ltd, Singapore, 2004
3. Lewis, E.E., Introduction to Reliability Engineering, John Wiley & Sons, 1995.
4. Modarres, Reliability and Risk analysis, Mara Dekker Inc., 1993.
5. Kapur K.C. and Lamberson L.R., Reliability in Engineering Design, John Wiley & Sons, 1977

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 301(E) VIBRATION ANALYSIS AND CONTROL

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *(i) To understand the fundamentals of vibration and its practical applications.*
(ii)To understand the working principle and operations of various vibrations measuring instruments
(iii)To understand the various vibration control strategies

Module I (17 hours)

Introduction to vibration - Sources of vibration - Mathematical models - Displacement, velocity and acceleration - Review Of single degree freedom systems - Vibration isolation - Vibrometers and accelerometers - Response to arbitrary and non-harmonic excitations – Transient vibration – Impulse loads - Critical speed of shaft-rotor systems. Introduction to two degree freedom system - Free vibration of undamped and damped - Forced vibration with harmonic excitation system –Coordinate couplings and principal coordinates.

Module II (11 hours)

Multi degree freedom system – Influence coefficients and stiffness coefficients - Flexibility matrix and Stiffness matrix – Eigen values and Eigen vectors – Matrix iteration method – Approximate methods: Dunkerley, Rayleigh's, and Holzer method -Geared systems - Eigen Values & Eigen vectors for large system of equations using sub space, Lanczos method - Continuous system: Vibration of string, shafts and beams.

Module III (10 hours)

Specification of vibration limits – Vibration severity standards - Vibration as condition monitoring tool -Vibration isolation methods - Dynamic vibration absorber, Torsional and pendulum type absorber - Damped vibration absorbers - Static and dynamic balancing - Balancing machines - Field balancing – Vibration control by design modification - Active vibration control.

Module I V (11 hours)

Vibration analysis overview - Experimental methods in vibration analysis - Vibration measuring instruments - Selection of sensors- Accelerometer mountings – Vibration exciters - Mechanical, hydraulic, electromagnetic and electrodynamics – Frequency measuring instruments - System identification from frequency response - Testing for resonance and mode shapes.

References:

1. Rao, S.S., Mechanical Vibrations, Addison Wesley Longman, 1995.
2. Thomson, W.T., Dahleh M.D. and Chandramouli P., Theory of Vibration with Applications, Pearson Education, New Delhi, 2008
3. Ramamurti V, "Mechanical Vibration Practice with Basic Theory", Narosa, New Delhi, 2000.
4. S. Graham Kelly and Shashidar K. Kudari, "Mechanical Vibrations", Tata McGraw –Hill Publishing Com. Ltd, New Delhi, 2007

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:
Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	**Module II**	**Module III**	**Module IV**
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 302(A) CO GENERATION & WASTE HEAT RECOVERY SYSTEM

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To understand the concept of energy engineering and waste heat recovery system.*

Module I (13 hours)

Introduction – principles of thermodynamics – cycles – topping – bottoming – combined cycle – organic ranking cycles – performance indices of cogeneration systems – waste heat recovery – sources and types – concept of tri generation.

Module I (13 hours)

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 etc., 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.

Module I (13 hours)

Selection criteria for waste heat recovery technologies – recuperators – Regenerators – economizers – plate heat exchangers – thermic fluid heaters – Waste heat boilers – classification, location, service conditions, design Considerations – fluidized bed heat exchangers – heat pipe exchangers – heat pumps – sorption systems

Module I (13 hours)

Investment cost - economic concept - measure of economic performance – procedure for economic analysis – examples – procedure for optimised system selection and design – load curves – sensitivity analysis – regulatory and financial frame work for cogeneration and waste heat recovery systems.

References:

1. Charles H Butler : Cogeneration. McGraw Hill Book Co.
2. EDUCOGEN : The European Educational tool for Cogeneration.
3. Horlock J H : Cogeneration-Heat and Power, Thermodynamics and Economics. Oxford
4. Institute of Fuel ,London. Waste heat recovery, Chapman and Hal Publishers.
5. Sengupta Subrata, Lee SS EDS, Waste heat utilisation and management. Hemisphere Washington

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks
Question pattern:
Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 302 (B) WIND ENERGY AND ITS UTILIZATION

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To understand various methods available for utilization of wind energy.*

Module I (14 hours)

Historical developments, latest developments, state of art of wind energy technology, turbine rating, cost of energy, wind power plant economics, installation and operation costs, decommissioning, Indian scenario and worldwide developments, present status and future trends.

Nature of atmospheric winds; wind resource characteristics and assessment; anemometry; wind statistics; speed frequency distribution, effect of height, wind rose, Weibull distribution, atmospheric turbulence, gust wind speed, effect of topography.

Module II (14 hours)

Aerodynamics of aerofoil; lift; drag; stall; effect of Reynold's number; actuator disc; momentum theory and Betz coefficient; design of wind turbine blade; effect of stall and blade pitch on coefficient of power vs tip speed ratio and cut-out wind speeds, blade materials. Vertical and horizontal axis turbines, design characteristics, multiple stream tube theory, vortex wake structure; tip losses; rotational sampling, wind turbine design programs, aerodynamic loads, tower shadow, wind shear, blade coning, gyroscopic, transient and extreme loads. Aerodynamic damping and stability, teetering motion, stiff and soft towers, Power train dynamics.

Module III (12 hours)

Pitch control, yaw control, Electrical and Mechanical aerodynamic braking, teeter mechanism. Wind turbine dynamics with DC and AC generators: induction and synchronous generators, variable speed operation, effect of wind turbulence. Power electronics Converter and Inverter interfaces for wind energy utilization system for isolated and grid connected system.

Module IV (12 hours)

Wind farm electrical design, Planning of wind farms, special application for developing countries, maintenance and operation, wind farm management, site selection. Environmental assessment; noise, visual impact etc. Instrumentation, data loggers, remote monitoring and control.

References:

1. Paul Gipe, Wind Energy Comes of Age, John Wiley & Sons Inc.
2. Ahmed: Wind Energy Theory and Practice, PHI, Eastern Economy Edition, 2012
3. L.L. Freris, Wind Energy Conversion System, Printice Hall.
4. Tony Burton et al, Wind energy Hand Book, John Wiley & Sons Inc.
5. Directory, Indian Wind Power 2004, CECL, Bhopal.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 302 (C) ELECTRICAL ENERGY SYSTEMS AND MANAGEMENT

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To understand various methods of energy conservation & heat recovery systems*

Module I (13 hours)

Overall structure of electrical systems – Supply and demand side – Economic operation – Input-output curves – Load sharing – Industrial Distribution – Load profiling – Electricity tariff types and calculation – Reactive Power – Power factor – Capacitor sizing – Capacitor losses, location, placement and maintenance – Case studies.

Module II (13hours)

Energy efficiency – Energy accounting, monitoring and control – Electricity audit instruments – Energy consumption models – Specific Energy Consumption – ECO assessment and Evaluation methods – Transformer loading/efficiency analysis – Feeder loss evaluation – Lighting – Energy efficient light sources – Domestic/commercial/industrial lighting – Lighting controls – Energy conservation in lighting schemes – Luminaries – Case studies.

Module III (13 hours)

Types and operating characteristics of electric motors – Energy efficient control and starting – Load matching – Selection of motors – Efficiency and load analysis – Energy efficiency – High efficiency motors – Industrial drives – Control schemes – Variable speed drives and Energy conservation schemes – Pumps and fans – Efficient control strategies – Over-sizing - Case studies.

Module IV (13 hours)

Electric loads of air conditioning and refrigeration – Energy conservation – Power consumption in compressors – Energy conservation measures – Electrolytic process – Electric heating – Furnace operation and scheduling – Cogeneration schemes – Optimal operation – Case studies – Computer controls – Software – EMS.

References:

1. IEEE Bronze Book: IEEE Standard 739-1984 – Recommended Practice for Energy Conservation and Cost Effective Planning in Industrial Facilities, IEEE Publications, 1996.
2. A.P.W. Thumann: Plant Engineers and Managers Guide to Energy conservation, 7e, UNR, 1977.
3. H. Partab, Art and Science of Utilisation of Electrical Energy, Pritam, 1985.
4. S.C. Tripathy, Electric Energy Utilization and Conservation, Tata McGraw Hill, 1991.
5. W.C. Turner, Energy Management Handbook, 2e, Fairmont press, 1993.
6. UNESCAP- Guide Book on Promotion of Sustainable Energy Consumption (www.unescap.org/enrd/energy)

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 302 (D) ENERGY CONSERVATION & HEAT RECOVERY SYSTEMS

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To understand various methods of energy conservation & heat recovery systems*

Module I (13 hours)
Energy consumption and potential for energy conservation in industry-thermodynamics of energy conservation-energy flows-energy auditing-technologies for energy conservation-thermal insulation. waste heat recovery systems, thermal energy storage, heat exchanger, heat pumps, heat pipes, waste heat to mechanical energy conversion systems. design for conversion of energy. Applications and case studies.

Module II (13hours)
Definition of energy management - Energy conservation schemes - Optimizing steam usage - Waste heat management - Insulation - Optimum selection of pipe size – Energy conservation in space conditioning – Energy and cost indices - Energy diagrams – Energy auditing - Thermodynamic availability analysis – Thermodynamic efficiencies - Available energy and fuel.

Module III (13 hours)
Thermodynamic analysis of common unit operations - Heat exchange - Expansion - Pressure let down - Mixing-Distillation - Combustion air pre-heating – Systematic design methods - Process synthesis - Application to cogeneration system – Thermo-economics - Systematic optimization - Improving process operations – Chemical reactions - Separation - Heat transfer - Process machinery - System interaction and economics

Module IV (13 hours)
Potential for waste heat recovery - Direct utilization of waste heat boilers – Use of heat pumps – Improving boiler efficiency - Industrial boiler inventory – Use of fluidized beds - Potential for energy conservation – Power economics - General economic problems - Load curves - Selections of plants - Specific economic energy problems - Energy rates.

References:

1. Kenney W F- Energy conservation in the Process industries
2. Chiogioji M H- Industrial energy conservation
3. Bernhardt G A. Sjritsju & Vopat W A – Power station engineering & economy
4. Thumann, Albert PE- Plant Engineers and Managers Guide Energy Conservation
5. Dubin F B-Energy conservation standards
6. A.P.E. Thummann: Fundamentals of Energy Engineering, Prentice Hall, 1984
7. M.H. Chiogioji: Industrial Energy Conservation, Marcel Dekker, 1979
8. W. R. Murphy and G. McKay: Energy Management, Butterworth-Heinemann, 2001

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 302 (E) ENERGY MODELING, ECONOMICS AND MANAGEMENT

Teaching scheme: 3 hours lecture and 1 hour tutorial per week **Credits:** 4

Objectives: *To understand the concepts of energy demand forecasting and management of projects*

Module I (14 hours)

Models and modeling approaches: Input output analysis, energy demand analysis and forecasting, economics of stand alone power supply systems, project management. Macroeconomic Concepts-Measurement of National Output-Investment Planning and Pricing – Economics of Energy Sources – Reserves and Cost Estimation. Multiplier Analysis – Energy and Environmental Input / Output Analysis-Energy Aggregation-Econometric Energy Demand Modeling-Overview of Econometric Methods. Methodology for Energy Demand Analysis – Methodology for Energy Technology Forecasting-Methodology for Energy Forecasting-Sectoral Energy Demand Forecasting. Solar Energy-Biomass Energy-Wind Energy and other Renewable Sources of Energy – Economics of Waste Heat Recovery and Cogeneration –Energy Conservation Economics. Cost Analysis – Budgetary Control-Financial Management-Techniques for Project Evaluation.

Module II (12hours)

Basic concept of econometrics and statistical analysis: The 2-variable regression model; The multiple regression model; Tests of regression coefficients and regression equation; Econometric techniques used for energy analysis and forecasting with case studies form India; Operation of computer package Input – Output Analysis, Basic concept of Input-output analysis; concept of energy multiplier and implication of energy multiplier for analysis of regional and national energy policy; Energy and environmental Input – Output analyses using I-O model.

Module III (13 hours)

Energy Modeling: Interdependence of energy-economy-environent; Modeling concept, and application, Methodology of energy demand analysis; Methodology for energy forecasting; Sectoral energy demand forecasting; Interfuel substitution models; SIMA model, and I-O model for energy policy analysis; Simulation and forecasting of future energy demand consistent with macroeconomic parameters in India; Energy Economics and Policies: National and Sectoral energy planning; Integrated resources planning; Energy pricing.

Module IV (13 hours)

Project Evaluation & Management: Financial analysis: Project cash flows, time value of money, life cycle approach & analysis, conception, definition, planning, feasibility and analysis; Project appraisal criteria; Risk analysis; Project planning matrix; Aims oriented project planning; Social cost benefit analysis. Network analysis for project management; Time estimation; Critical path determination; PERT, CPM and CERT: Fuzzy logic analysis; Stochastic based formulations; Project evaluation techniques; Funds planning; Project material management, evaluation & analysis; Implementation and monitoring; Performance indices; Case studies.

References:

1. Energy Policy Analysis and Modeling, M. Munasinghe and P. Meier Cambridge University Press, 1993.
2. The Economics of Energy Demand: A Survey of Applications, W.A Donnelly New York, 1987.
3. Econometrics Models and Economic Forecasts, S. Pindyck and Daniel L Rubinfeld, 3rd edition McGraw Hill, New York 1991.
4. Sectoral Energy Demand Studies: Application of the END-USE Approach to Asian Countries, UN-ESCAP, New York 1991.

5. Guide Book on Energy – Environment Planning in Developing Countries – Methodological Guide on Economic Sustainability and Environmental Betterment Through Energy Savings and Fuel Switching in Developing Countries, UN-ESCAP, New York 1996.
6. Forecasting Methods and Applications, S.Makridakis, Wiley 1983.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced to students at the beginning of the semester by the teacher.

Semester end examination: 100 marks

Question pattern:

Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	**Module II**	**Module III**	**Module IV**
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

MEA10 303 (P): INDUSTRIAL TRAINING

Teaching scheme: 1 hour per week **Credits:** 1

The students have to undergo an industrial training of minimum two weeks in an industry preferably dealing with energy systems engineering during the semester break after second semester and complete within 15 calendar days from the start of third semester. The students have to submit a report of the training undergone and present the contents of the report before the evaluation committee constituted by the department. An internal evaluation will be conducted for examining the quality and authenticity of contents of the report and award the marks at the end of the semester.

Internal continuous assessment: Marks 50

MEA10 304 (P): MASTERS RESEARCH PROJECT (PHASE – I)

Teaching scheme: 22 hours per week **Credits:** 6

Objective:

To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.

The project work can be a design project / experimental project and or computer simulation project on engineering or any of the topics related with energy engineering stream. The project work is allotted individually on different topics. The students shall be encouraged to do their project work in the parent institute itself. If found essential, they may be permitted to continue their project outside the parent institute subject to the conditions in clause 10 of M.Tech regulations. Department will constitute an Evaluation Committee to review the project work. The Evaluation committee consists of at least three faculty members of which internal guide and another expert in the specified area of the project shall be two essential members.

The student is required to undertake the masters research project phase-I during the third semester and the same is continued in the 4^{th} semester.(Phase-II). Phase-I consists of preliminary thesis work, two reviews of the work and the submission of preliminary report. First review would highlight the topic, objectives, methodology and expected results. Second review evaluates the progress of the work, preliminary report and scope of the work which is to be completed in the 4^{th} semester.

Internal Continuous assessment:

First Review:

Guide	50 marks
Evaluation Committee	50 marks

Second review:

Guide	100 marks
Evaluation Committee	100 marks

Total	**300 marks**

MEA10 401 (P): MASTERS RESEARCH PROJECT (PHASE-II)

Teaching scheme: 30 hours per week **Credits:** 12

Objectives:

To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.

Masters Research project phase-II is a continuation of project phase-I started in the third semester. Before the end of the fourth semester, there will be two reviews, one at middle of the fourth semester and other towards the end. In the first review, progress of the project work done is to be assessed. In the second review, the complete assessment (quality, quantum and authenticity) of the Thesis is to be evaluated. Both the reviews should be conducted by guide and Evaluation committee. This would be a pre qualifying exercise for the students for getting approval for the submission of the thesis. At least one technical paper is to be prepared for possible publication in journal or conferences. The technical paper is to be submitted along with the thesis. The final evaluation of the project will be external evaluation.

Internal Continues assessment:

First review:

Guide	50 marks
Evaluation committee	50 marks

Second review:

Guide	100 marks
Evaluation committee	100 marks

Semester end Examination:

Project evaluation by external examiner: 150 marks

Viva-voce by internal and external examiner: 150 marks (75 marks each)