ANNAMALAI UNIVERSITY

Faculty of Engineering and Technology

DEPARTMENT OF MECHANICAL ENGINEERING

M.E. Energy Engineering and Management

Choice Based Credit System

(Full Time & Part Time)

2019

DEPARTMENT OF MECHANICAL ENGINEERING

VISION

The Mechanical Engineering Department endeavors to be recognized globally for outstanding education and research leading to well qualified engineers, who are innovative, entrepreneurial and successful in advanced fields of mechanical engineering to cater the ever changing industrial demands and social needs.

MISSION

The Mechanical Engineering program makes available a high quality, relevant engineering education. The Program dedicates itself to providing students with a set of skills, knowledge and attitudes that will permit its graduates to succeed and thrive as engineers and leaders. The Program strives to

- Prepare its graduates to pursue life-long learning, serve the profession and meet intellectual, ethical and career challenges.

- Maintain a vital, state-of-the-art research enterprise to provide its students and faculty with opportunities to create, interpret, apply and disseminate knowledge.

Programme Educational Objectives (PEO)

This program imbibes excellent technical capabilities in the area of energy engineering and allied systems, effective communication skill in students, ensuring successful career and continuing their professional advancement through life-long learning. The programme educational objectives of Master in Energy Engineering and Management are

1. Have high level of technical competency combined with research and problem solving ability to generate innovative solutions in energy engineering or related areas using the acquired analytical, computational and experimental skills.

2. Graduates will have inculcated the ability to maintain high professionalism and ethical standards, effective technical presentation and writing skill and to work as a part of team on research projects.

3. To prepare the students to exhibit a high level of professionalism, integrity, environmental and social responsibility, and life-long independent learning ability

Programme Outcomes (PO)

PO1: An ability to acquire, apply and share in-depth knowledge in the area of Energy Engineering and Management

PO2: An ability to analyze real life problems in the field of Energy Engineering and arrive at sustainable solutions

PO3: An ability to conduct independent research and generate knowledge for the benefit of mankind.

PO4: An ability to effectively communicate through technical reports, presentations and scientific publications in general and, use the modern computer/ software tools to model and analyze energy engineering problems in particular.

PO5: An ability to work effectively in interdisciplinary teams to develop energy efficient systems for the society

PO6: An ability to apply engineering and scientific principles for effective management of energy systems

PO7: Graduates will demonstrate an ability to visualize and work on laboratory and multidisciplinary tasks.

PO8: An ability to engage in life-long independent learning with high level of enthusiasm and commitment

PO9: An ability to examine critically the outcomes of one's actions and make corrective measures subsequently

Mapping of POs with PEOs									
PEOs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
PEO1	✓		✓	✓					
PEO2		✓				✓		✓	
PEO3	✓	✓			✓		✓		✓
PEO4				✓	✓			✓	

FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M.E Specialization: Energy Engineering and Management

CURRICULUM - 2019

SEMESTER I									
Course Code	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**
MEEMPC11	**PC**	Thermodynamics and Combustion	3	-	-	25	75	100	3
MEEMPC12	**PC**	Fluid Mechanics and Heat transfer	3	-	-	25	75	100	3
MEEMPE13	**PE**	Program Elective-I	3	-	-	25	75	100	3
MEEMPE14	**PE**	Program Elective-II	3	-	-	25	75	100	3
MEEMMC15	**MC**	Research Methodology and IPR	2	-	-	25	75	100	2
MEEMCP16	CP	Thermodynamics and Combustion Laboratory	-	-	3	40	60	100	2
MEEMCP17	**CP**	Computer Laboratory	-	-	3	40	60	100	2
MEEMAC18	**AC**	Audit Course-I	2	-	-	-	-	-	0
			Total			205	495	700	**18**

SEMESTER II									
Course Code	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**
MEEMPC21	**PC**	Energy Conservation and Management	3	-	-	25	75	100	3
MEEMPC22	**PC**	Co-generation and Waste Heat Recovery Systems	3	-	-	25	75	100	3
MEEMPE23	**PE**	Program Elective-III	3	-	-	25	75	100	3
MEEMPE24	**PE**	Program Elective-IV	3	-	-	25	75	100	3
MEEMCP25	**OE**	Open Elective	-	-	3	40	60	100	3
MEEMOE26	**CP**	Solar and Heat Transfer Laboratory	-	-	3	40	60	100	2
MEEMTS27	**TS**	Industrial Training and Seminar / Mini project		Tr 2	S 2	40	60	100	2
MEEMAC28	**AC**	Audit Course-II	2	-	-	-	-	-	0
			Total			205	495	700	**19**

PC	**Program Core**	**CP**	Core Practical	**AC**	Audit Course
PE	**Program Elective**	**TS**	Industrial Training and Seminar	**PV**	Project work & Viva-voce
OE	**Open Elective**	**MC**	Mandatory Learning Course	**XX**	Branch code
				yy	M.E Specialization Code

SEMESTER III									
Course Code	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**
MEEMOE31	**PE**	Program Elective-V	3	-	-	25	75	100	3
MEEMOE32	**OE**	Open Elective	3	-	-	25	75	100	3
MEEMPV33	**PV-I**	Project work & Viva-voce Phase-I	-	Pr 16	S 4	40	60	100	10
			Total			90	210	300	**16**

SEMESTER IV									
Course Code	**Category**	**Course**	**L**	**T**	**P**	**CA**	**FE**	**Total**	**Credits**
MEEMPV41	**PV-II**	Project work & Viva-voce Phase-II	-	Pr 24	S 6	40	60	100	15
			Total			40	60	100	**15**

Program Electives

1. MEEMPESCN Measurements and Controls in Thermal Engineering
2. MEEMPESCN Energy Conversion Techniques
3. MEEMPESCN Solar Energy and Wind Energy
4. MEEMPESCN Bio Energy Conversion Technologies
5. MEEMPESCN Boiler Technology
6. MEEMPESCN Fluidized Bed Systems
7. MEEMPESCN Design of Heat Exchangers
8. MEEMPESCN Computational Heat Transfer
9. MEEMPESCN Energy Storage Technologies
10. MEEMPESCN Renewable Energy Systems
11. MEEMPESCN Biomass Energy- Conversion and Conservation Techniques
12. MEEMPESCN Biomass Gasification -Technology and Utilization
13. MEEMPESCN Energy Auditing
14. MEEMPESCN Waste management and Energy generation techniques

Open Electives

1. MEEMOESCN Nuclear Engineering
2. MEEMOESCN Fuels and Combustion
3. MEEMOESCN Numerical Analysis in Engineering
4. MEEMOESCN Energy Management in Buildings
5. MEEMOESCN Advanced Power Plant Engineering

Audit courses

1. MEEMACSCN English for Research Paper Writing
2. MEEMACSCN Disaster Management
3. MEEMACSCN Sanskrit for Technical Knowledge
4. MEEMACSCN Value Education
5. MEEMACSCN Constitution of India
6. MEEMACSCN Pedagogy Studies
7. MEEMACSCN Stress Management by Yoga
8. MEEMACSCN Personality Development through Life Enlightenment Skills

FIRST SEMESTER

MEEMPC11	THERMODYNAMICS AND COMBUSTION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To provide knowledge of energy, basic laws governing energy conversion
- To introduce advanced concepts in thermodynamics.
- To prepare the students to present theoretical, semi-theoretical and empirical models for the prediction of thermodynamic properties.

First law and State postulates, Second law and Entropy, Availability and Irreversibility, Transient flow analysis

Nonreactive Ideal-Gas Mixture, PvT Behavior of Real gases and Real Gas mixture Generalized Thermodynamic Relationship

Combustion and Thermo-chemistry, Second law analysis of reacting mixture, Availability analysis of reacting mixture, Chemical equilibrium.

Statistical thermodynamics, statistical interpretations of first and second law and Entropy.

Third law of thermodynamics, Nerst heat theorem.

REFERENCES:

1. Cengel, “Thermodynamics”, Tata McGraw Hill Co., New Delhi, 1980.
2. Howell and Dedcius, “Fundamentals of Engineering Thermodynamics”, McGraw Hill Inc.,U.S.A.
3. Van Wylen & Sonntag, “Thermodynamics”, John Wiley and Sons Inc., U.S.A.
4. Jones and Hawkings, “Engineering Thermodynamics”, John Wiley and Sons Inc., U.S.A,2004.
5. Holman, “Thermodynamics”, McGraw Hill Inc., New York, 2002.
6. Faires V.M. and Simmag, “Thermodynamics”, Macmillan Publishing Co. Inc., U.S.A.
7. Rao Y.V.C., “Postulational and Statistical Thermodynamics”, Allied Publishers Inc, 1994.

COURSE OUTCOMES:

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

1. Gain knowledge of exergy, basic laws governing energy conversion in multi component systems and application of chemical thermodynamics.
2. Aware of advanced concepts in thermodynamics.
3. Able to present theoretical, semi-theoretical and empirical models for the prediction of thermodynamic properties.
4. Apply fundamental principles of thermodynamics to non-ideal models of numerous engineering devices
5. Understand statistical thermodynamics.

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓	✓			✓	✓		✓	✓
CO2	✓	✓						✓	
CO3		✓		✓		✓			
CO4	✓	✓							✓
CO5	✓	✓							

✓

MEEMPC12	**FLUID MECHANICS AND HEAT TRANSFER**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

- To develop the skills to correlate the Physics with applications.
- To understand the laws of fluid flow and Heat transfer.
- To learn the advanced topics in heat transfer

Basic Equation, Potential Flow Theory and Boundary Layer Concept:

Three dimensional continuity equation – differential and integral forms – equations of mass, momentum and Energy and their engineering applications. Rotational and irrotational flows – circulation – vorticity – stream and potential functions. Boundary Layer - displacement and momentum thickness – laminar and turbulent boundary layers in flat plates – circular pipes.

Incompressible and Compressible Flows:

Laminar and turbulent flow between parallel plates – flow through circular pipe – friction factor – smooth and rough pipes – Moody diagram – losses during flow through pipes. Pipes in series and parallel – transmission of power through pipes. One dimensional compressible fluid flow – flow through variable area passage – nozzles and diffusers

Conduction and Radiation Heat Transfer:

Governing Equation and Boundary conditions, Extended surface Heat Transfer, Transient conduction – Use of Heisler's charts, Conduction with moving boundaries, Radiation Heat Transfer, Gas Radiation

Turbulent Forced Convective Heat Transfer:

Turbulence theory – mixing length concept – turbulence model – k Є model – analogy between heat and momentum transfer – Reynolds, Colburn, Prandtl turbulent flow in a tube – high speed flows.

Phase Change Heat Transfer and Heat Exchanger:

Condensation on bank of tubes – boiling – pool and flow boiling, Heat exchanger – Є – NTU approach and design procedure – compact heat exchangers

REFERENCES

1. Anderson, J.D., Fundamentals of Aerodynamics, McGraw Hill, Boston, 2001.
2. Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw-Hill Co., 1985.

3. Streeter, V.L., Wylie, E.B., and Bedford, K.W., Fluid Mechanics, WCB McGraw Hill, Boston, 1998.
4. Bansal,R.K., Fluid Mechanics, Saurabh and Co., New Delhi, 1985.
5. Holman.J.P., Heat Transfer, Tata Mc Graw Hill, 2002.
6. Ghoshdastidar.P.S., Heat Transfer, Oxford University Press, 2004

COURSE OUTCOMES

Upon completion of the course, students will be able to

1. Solve fluid flow problems
2. Understand compressible and incompressible flows
3. Solve transient heat transfer problems
4. Know the concept of turbulent teat transfer
5. Employ the concepts of Heat Transfer and fluid flow in the field of energy applications.

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1		✓		✓		✓		✓	
CO2	✓	✓						✓	
CO3	✓	✓				✓			
CO4	✓	✓				✓			
CO5	✓	✓	✓					✓	✓

MEEMMC15	**RESEARCH METHODOLOGY AND IPR**	**L**	**T**	**P**	**C**
		2	**0**	**0**	**2**

COURSE OBJECTIVES:

- To formulate research problems
- To analyze the information related to results
- To introduce research ethics

Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations

Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development.
International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.

New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.

REFERENCES:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5. Mayall , "Industrial Design", McGraw Hill, 1992.
6. Niebel , "Product Design", McGraw Hill, 1974.
7. Asimov, "Introduction to Design", Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

COURSE OUTCOMES:

At the end of this course, students will be able to

1. Understand research problem formulation.
2. Analyze research related information
3. Follow research ethics
4. Enhance their writing skills
5. Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓	✓	✓	✓		✓			
CO2	✓	✓	✓	✓		✓			
CO3	✓	✓	✓	✓		✓			
CO4	✓	✓	✓	✓		✓			
CO5	✓	✓	✓	✓		✓			

✓

MEEMCP16	THERMODYNAMICS AND COMBUSTION LABORATORY	L	T	P	C
		0	0	3	2

COURSE OBJECTIVES

- To conduct the load test, speed test and Heat Balance Test of a single and double cylinder diesel engine.
- To evaluate the performance of steam boiler, turbine and condenser.
- To make the students understand the working principle of various types of governors, balancing systems, Cam analyzer, Torsional vibration of single rotor system, whirling speed concept, action of forces in gyroscope.

List of Experiments

1. Study and Performance test on Kaeser air compressor test rig.
2. Heat balance test and air fuel determination on a Diesel Engine
3. Effect of injection pressure on the performance and emission of Diesel Engine.
4. Determination of damping coefficient in damping torsional oscillation.
5. Experimentation of pressure processes station by PID control.
6. Demonstrate the gyroscopic effects and determination of gyroscopic couple.
7. Performance evaluation of loco type boiler.
8. Performance evaluation of Greenbat turbine with condenser.
9. Performance evaluation of reader vertical steam engine.

COURSE OUTCOMES

Upon completing this course, students should be able to:

1. Gain knowledge about the combustion principles.
2. Analyze the performance of internal combustion engines
3. Analyze the performance of steam boiler, turbine and condenser.
4. Supplement the principles learnt in kinematics and Dynamics of Machinery.
5. Work as a team to promote lifelong learning.

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓				✓	✓	✓		
CO2	✓				✓	✓	✓		
CO3	✓				✓	✓	✓		
CO4	✓				✓	✓	✓		
CO5	✓				✓	✓	✓		

✓

MEEMCP17	COMPUTER LABORATORY - II	L	T	P	C
		0	0	3	2

COURSE OBJECTIVES

- To understand the strength of OOPS using c++
- To impart programming skills in C++ programming.
- To introduce the basics of MAT LAB.

List of Experiment

Search, generate, manipulate data using MS office/ Open Office
Presentation and Visualization – graphs, charts, 2D, 3D
C++, Programming,
Simple MATLAB Exercises
Simple CATIA Exercises

COURSE OUTCOMES

Upon completing this course, students should be able to:

1. Able to prepare slides and graphs
2. Write and compile programmes in C++
3. Develop assembly drawings with different views using auto cad
4. Solve simple mathematical models using MATLAB.
5. Write simple exercises in CATIA

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓				✓	✓	✓		
CO2	✓				✓	✓	✓		
CO3	✓				✓	✓	✓		
CO4	✓				✓	✓	✓		
CO5	✓				✓	✓	✓		

✓

SECOND SEMESTER

ME EM PC21	ENERGY CONSERVATION AND MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- Familiarizing with management, especially with management in energy sector engineering.
- Fundamentals of product strategy management. Studying methods of energy accounting and energy auditing in energy sector, industry and final consumption.
- Finding opportunities to increase the rational use of energy.

Introduction:

Energy Scenario - Principles and Imperatives of Energy Conservation - Energy Consumption Pattern - Resource Availability - Role of Energy Managers in Industries Thermal Energy Auditing: Energy Audit - Purpose, Methodology with respect to Process Industries - Power Plants, Boilers etc. - Characteristic Method Employed in Certain Energy Intensive Industries - Various Energy Conservation Measures in Steam System - Losses in Boiler, Methodology of Upgrading Boiler Performance.

Energy Conservation:

Energy Conservation in Pumps, Fans & Compressors, Air conditioning and refrigeration systems, Steam Traps - Types, Function, Necessity.

Role of Instrumentation in Energy Conservation:

Total Energy Systems - Concept of Total Energy - Advantages & Limitations - Total Energy System & Application - Various Possible Schemes Employing Steam Turbines Movers Used in Total Energy Systems - Potential & Economics of Total Energy Systems.

Electrical Energy Auditing:

Potential areas for Electrical Energy Conservation in Various Industries - Energy Management Opportunities in Electrical Heating, Lighting System, Cable Selection - Energy Efficient Motors - Factors Involved in Determination of Motor Efficiency- Adjustable AC Drives, Application & its use Variable Speed Drives Belt Drives.

Energy Management:

Importance of Energy Management, Energy Economics - Discount Rate, Payback Period, Internal Rate of Return, Life Cycle Costing.

REFERENCES

1. CB Smith, Energy Management Principles, Pergamon Press, New York, 1981
2. Hamies, Energy Auditing and Conservation ; Methods, Measurements, Management & Case Study, Hemisphere, Washington, 1980.
3. Trivedi, PR, Jolka KR, Energy Management, Commonwealth Publication, New Delhi, 1997.
4. Witte, Larry C, Industrial Energy Management & Utilization, Hemisphere Publishers, Washington, 1988.
5. Diamant, RME, Total Energy, Pergamon, Oxford, 1970

COURSE OUTCOMES:

Upon completion of this course, the students will be able to

1. Perform energy auditing for the energy consumption in industries.
2. Know the different types of lightings
3. Understand the energy conservation measures
4. Understand the significance of energy conservation in major utilities
5. Learn the concept of energy economics

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓	✓					✓	✓	
CO2	✓				✓				
CO3	✓	✓			✓	✓			
CO4	✓	✓			✓	✓			
CO5	✓	✓			✓	✓			✓

✓

MEEMPC22	**CO-GENERATION AND WASTE HEAT RECOVERY SYSTEMS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

- To gain fundamental knowledge in energy generation, heat transfer in thermal engineering.
- To reduce the impact global warming for betterment of living things to serve healthy life.
- To learn the principles of waste heat recovery

Cogeneration

Introduction - Principles of Thermodynamics - Combined Cycles - Topping - Bottoming - Organic Rankine Cycles - Advantages of Cogeneration Technology

Application & Techno Economics of Cogeneration

Cogeneration Application in various Industries like Cement, Sugar Mill, Paper Mill etc. Sizing of Waste Heat Boilers - Performance Calculations - Part Load Characteristics. Selection of Cogeneration Technologies - Financial Considerations-Operating and Investments - Costs of Cogeneration.

Waste Heat Recovery

Introduction - Principles of Thermodynamics and Second Law - Sources of Waste Heat Recovery - Diesel Engines and Power Plant etc.

Waste Heat Recovery Systems, Applications & Techno Economics

Recuperators - Regenerators - Economizers - Plate Heat Exchangers - Waste Heat Boilers - Classification, Location, Service Conditions, Design Considerations, Unfired Combined Cycle - Supplementary Fired Combined Cycle - Fired Combined Cycle. Applications in Industries - Fluidized Bed Heat Exchangers - Heat Pipe Exchangers - Heat Pumps - Thermic Fluid Heaters Selection of Waste Heat Recovery Technologies - Financial Considerations - Operations and Investment Costs of Waste Heat Recovery.

Environmental Considerations

Environmental considerations for Cogeneration and Waste Heat Recovery - Pollution

REFERENCES

1. Charles H Butler, Cogeneration, McGraw Hill Book Co., 1984.
2. Horlock JH, Cogeneration - Heat and Power, Thermodynamics and Economics, Oxford, 1987.
3. Institute of Fuel, London, Waste Heat Recovery, Chapman & Hall Publishers, London, 1963.
4. Sengupta Subrata, Lee SS EDS, Waste Heat Utilization and Management, Hemisphere, Washington, 1983.
5. De Nevers, Noel., Air Pollution Control Engineering, Mcgraw Hill, New York, 1995.

COURSE OUTCOMES

Upon completion of the course, students will be able to

1. Acquire fundamental knowledge in co-generation.
2. Understand the applications and economics of co-generation
3. Learn the principles of waste heat recovery.
4. Learn the devices available for waste heat recovery
5. Solve real world problems and reduce the impact global warming for betterment of living things to serve healthy life.

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓					✓		✓	
CO2	✓			✓		✓		✓	✓
CO3	✓	✓	✓			✓		✓	
CO4		✓				✓	✓	✓	✓
CO5		✓	✓		✓	✓			✓

MEEMCP26	**SOLAR AND HEAT TRANSFER LABORATORY**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**2**

COURSE OBJECTIVES

- To make the students understand the modes of heat transfer and to conduct the trails on various experiments to analyze the heat transfer parameters.
- To understand the working of refrigeration trainer and air conditioners.
- To study the basics of solar energy.

List of Experiments

1.Natural convection from vertical cylinder
2.Experiments on finned tube heat exchanger
3.Experiments on unsteady state heat transfer apparatus.
4.Determination of thermal conductivity of metal rod.
5.Experiments on composite wall apparatus
6.Performance test on central A/C plant
7.Performance test on vapor absorption refrigeration system
8.Performance test on Solar still
9.Performance test on Solar concentrator test rig.
10.Performance test on Solar cooker.

COURSE OUTCOMES

Upon completing this course, students should be able to:

1. Understand the behavior of a system at different operating conditions
2. Understand the various modes of heat transfer
3. Understand the working of refrigeration systems
4. Understand the usage of different refrigeration tools.
5. Learn the basics of solar energy, how to determine solar intensity, and how to estimate daily and annual solar energy potential at each location.

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓				✓	✓	✓		
CO2	✓				✓	✓	✓		
CO3	✓				✓	✓	✓		
CO4	✓				✓	✓	✓		
CO5	✓				✓	✓	✓		

✓

MEEMTS27	**INDUSTRIAL TRAINING AND SEMINAR / MINI PROJECT**	**L**	**T**	**P**	**C**
		0	**2**	**2**	**2**

COURSE OBJECTIVES:

- To train the students in the field work related the Mechanical Engineering and to have a practical knowledge in carrying out Structural field related works.
- To train and develop skills in solving problems during execution of certain works related to Mechanical Engineering.

The students individually undergo a training program in reputed concerns in the field of Mechanical Engineering during the summer vacation (at the end of second semester for full - time / * fourth semester for part - time) for a minimum stipulated period of four weeks. At the end of the training, the student has to submit a detailed report on the training he had. Within ten days from the commencement of the third semester for Full-time / fifth semester for part-time. The students will be evaluated by a team of staff members nominated by head of the department through a viva-voce examination.

* - *Four weeks during the summer vacation at the end of II Semester.*

COURSE OUTCOMES:

1. The students can face the challenges in the practice with confidence.
2. The student will be benefited by the training with managing the situation arises during the execution of works related to Mechanical Engineering.

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓				✓	✓	✓		
CO2	✓				✓	✓	✓		

THIRD SEMESTER

MEEMPV33	PROJECT WORK & VIVA-VOCE PHASE-I	L	T	P	C
		0	16	4	10

COURSE OBJECTIVES

- To enhance the research and development activities of the students
- To enhance the writing skills

COURSE OUTCOMES

Upon completing this course, students should be able to:

1. Understand the significance of research
2. Gain hands on experience in collection of literature
3. Improve their presentation skills
4. Enhance their thesis writing skills
5. Apply the knowledge gained from theoretical and practical courses in solving problems, so as to give confidence to be creative, well planned, organized, coordinated in their project work phase – II.

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓				✓	✓	✓		
CO2	✓				✓	✓	✓		
CO3	✓				✓	✓	✓		
CO4	✓				✓	✓	✓		
CO5	✓				✓	✓	✓		

✓

FOURTH SEMESTER

MEEMPV41	PROJECT WORK & VIVA-VOCE PHASE-II	L	T	P	C
		0	24	6	15

COURSE OBJECTIVES

- To improve the student research and development activities.
- To improve presentation and report preparation skills.

COURSE OUTCOMES:

Upon completing this course, students should be able to:

1. Understand the significance of research
2. Gain hands on experience in collection of literature
3. Improve their presentation skills
4. Enhance their thesis writing skills
5. Apply the knowledge in solving problems, so as to give confidence to be creative, well planned, organized, coordinated project outcome of the aimed work.

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓				✓	✓	✓		
CO2	✓				✓	✓	✓		
CO3	✓				✓	✓	✓		
CO4	✓				✓	✓	✓		
CO5	✓				✓	✓	✓		

✓

PROGRAM ELECTIVES

MEEMSCN	MEASUREMENTS AND CONTROLS IN THERMAL ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To equip the students with necessary foundation for effectively analyzing and solving the problems associated in thermal engineering field.
- To deliver comprehensive education in thermal Engineering to ensure that the students have core competency to be successful in industry/ research laboratory and motivate them to pursue higher studies and research in interrelated areas.
- To encourage the students to take up real life and/or research related problems and to create innovative solutions of these problems through comprehensive analysis and designing.

Measurement Characteristics

Measuring instruments-static and dynamic characteristics - experimental error analysis-systematic and random errors- statistical analysis – Uncertainty- experimental planning and selection of measuring instruments.

Concepts of Instrumentation

Basic instruments for the measurement of temperature- torque-strain gauges- pressure-velocity-current-flow and level.

Measurements of Surface Temperature

Measurements of conductivity remote sensing of temperature- coefficient of conduction-insulating materials –convection and radiation - measurements of conduction in porus insulating material- measurement of pH value- Oxygen Concentration.

Gas Analysis

Measurements of Co_2, No_2, Co and hydrocarbons and So_2, Use of gas Chromatography - fuel analysis- Measurements of Smoke- Dust and Moisture.

Microprocessor Based Instrumentation and Data Logging System

Controllers and displays in power plants- pneumatic and electronic controls- typical control system in power plant control- loop interaction- nuclear reactor control systems.

REFERENCES

1. C.S.Rangan, G.R.Sharma, V.S.V.Mani, Instrumentation Devices and systems, Tata McGraw-Hill, New Delhi (1983).
2. J.P.Holman - Experimental methods for Engineers, McGraw-Hill (1988).
3. Doeblin, Measurment System Application and Design-McGraw-Hill(1978)
4. Barnery, Intelligent Instrumentation, Prentice Hall of India (1988)
5. http://www.eets.com
6. http://www.thermomax.com

COURSE OUTCOMES

Upon completing this course, students should be able to:

1. Ability to acquire, apply and share in-depth knowledge in the area of thermal engineering.
2. Understand the significance of instrumentation

3. Graduates will demonstrate skills to use modern engineering tools, software and equipment to analyze and solve complex engineering problems.
4. Graduate will acquire knowledge about current issues/advances in engineering practices.
5. Learn microprocessor based instrumentation systems

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓				✓	✓			
CO2		✓				✓			✓
CO3				✓		✓	✓		
CO4		✓				✓			✓
CO5	✓	✓				✓			

✓

MEEMSCN	ENERGY CONVERSION TECHNIQUES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To analyze the pros and cons of conventional energy and direct energy conversion techniques for converting one form of energy to another.
- To study the various forms of energy conversion techniques and production of electrical energy.
- To understand the necessity of energy storage systems and the thermodynamic and kinetic principles of fuel cells.

Introduction

Energy - Classification – Sources – Utilization – Principle of energy conversion – Biomass - Solar energy.

Production of Thermal Energy and Mechanical Energy

Conversion of mechanical, electrical, electromagnetic and chemical energy-conversion of thermal energy – turbines – Electromechanical conversion.

Production of Electrical Energy

Conversion of Thermal energy into electricity - Chemical energy into Electricity – Electromagnetic energy into Electricity – Mechanical energy into Electricity.

Energy Storage Systems

Introduction - Storage of Mechanical energy, Electrical energy, Chemical energy, Thermal energy. Fuel Cells: Thermodynamic and kinetics of fuel cell processes – Fuel cell performance – Types of fuel cells – Advantages – Fuel cell applications.

Thermal Biomass Conversion

Combustion, pyrolysis, Gasification and Liquefaction-Biological Conversion-Methanol, Ethanol Production -Fermentation-Anaerobic Digestion Biodegradation and Biodegradability of Substrate.

REFERENCES

1. Archie.W.Culp, Principles of Energy Conversion, McGraw-Hill Inc., New York, (1991).
2. Kordesch. K and Simader. G, Fuel Cell and Their Applications, Wiley-Vch., Germany (1996).
3. Kettari. M.A, Direct Energy Conversion, Addison-Wesley Pub. Co, (1997).
4. Hart. A.B and Womack G.J, Fuel Cells: Theory and Application, Prentice Hall New York Ltd., London (1989).
5. http ://www.ovonic.com
6. http ://www.iiec.org
7. www.alternativepower.com

COURSE OUTCOMES

1. Learn the principles of energy conversion
2. Learn energy storage systems
3. Awareness on the existence of various mechanisms for conversion of energy from one form to another and their merits and constraints.
4. Understand the production of electrical energy from different conversion methods.
5. Understand the working of various fuel cells, their relative advantages/disadvantages.

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓	✓				✓			
CO2	✓						✓		✓
CO3	✓	✓	✓						
CO4	✓	✓							
CO5	✓	✓						✓	

MEEMSCN	**SOLAR ENERGY AND WIND ENERGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To understand and analyze the present and future energy demand of world and nation and techniques to exploit the available renewable energy resources such as solar, bio-fuels, wind power, tidal and geothermal effectively

Solar Radiation

Availability - Measurement and Estimation - Isotropic and an Isotropic Models - Introduction to Solar Collectors (Liquid Flat - Plate Collector, Air Heater and Concentrating Collector) and Thermal Storage - Steady State and Transient Analysis - Solar Pond - Solar Refrigeration.

Modeling of Solar Thermal Systems and Simulations in Process Design

Design of Active Systems by f-chart and Utilizability Methods - Water Heating Systems - Active and Passive - Passive Heating and Cooling of Buildings - Solar Distillation - Solar Drying.

Photovoltaic Solar Cell

P:N Junction - Metal - Schottky Junction, Electrolyte - Semiconductor Junction, Types of Solar Cells - their Applications - Experimental Techniques to determine the

Characteristics of Solar Cells - Photovoltaic Hybrid Systems Photovoltaic Thermal Systems - Storage Battery - Solar Array and their Characteristics Evaluation - Solar Chargeable Battery.

Wind

Structure - Statistics - Measurements and Data Presentation - Wind Turbine Aerodynamics - Momentum Theories - Basic Aerodynamics - Airfoils and their Characteristics - HAWT-Blade Element Theory - Prandtl's Lifting Line Theory (prescribed wake analysis) - VAWT Aerodynamics - Wind Turbine Loads - Aerodynamic Loads in Steady Operation - Wind Turbulence - Yawed Operation and Tower Shadow.

Wind Energy Conversion System (WECS)

Siting - Rotor Selection - Annual Energy Output - Horizontal Axis Wind Turbine (HAWT) - Vertical Axis Wind Turbine - Rotor Design Considerations - Number of Blades - Blade Profile - 2/3 Blades and Teetering - Coning - Upwind/Downwind - Power Regulation - Yaw System - Tower - Synchronous and Asynchronous Generators and Loads - Integration of Wind Energy Converters to Electrical Networks - Inverters - Testing of WECS - WECS Control System - Requirements and Strategies - Miscellaneous Topics - Noise etc - Other Applications.

REFERENCES

1. L.L.Freris, Wind Energy Conversion Systems, Prentice Hall, 1990.
2. D.A.Spera, Wind Turbine Technology: Fundanental concepts of Wind Turbine Engineering, ASME Press.
3. S.P.Sukhatme-Solar Energy: principles of Thermal Collection and Storage, Tata McGraw-Hill (1984).
4. J.A.Duffie and W.A.Beckman-Solar Engineering of Thermal Processes-John Wiley (1991).
5. J.F.Kreider and F.Kreith-Solar Energy Handbook McGraw-Hill (1981).
6. http ://www.ises.ors
7. http :/www.windpower-monthly.com
8. www.solarpv.com

COURSE OUTCOMES

Upon completion of the course, the students will be able to

1. Know about the exploration of nonconventional energy resources and their effective tapping technologies.
2. Model solar thermal system
3. Determine the characteristics of solar thermal system
4. Understand wind turbine aerodynamics
5. Demonstrate the working of wind energy conversion system

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓		✓			✓			
CO2		✓	✓	✓					
CO3		✓			✓	✓			
CO4	✓		✓				✓	✓	
CO5		✓			✓	✓			✓

✓

MEEMSCN	BIO ENERGY CONVERSION TECHNOLOGIES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To pursue the various technologies for utilizing the bio-energy and its availability and conversion of bio-energy in the useful forms.
- Analyze elaborately the technologies available for conversion of biomass to energy in the technical update.
- Analyze the bio-energy conversion with respect to economical aspect and also in the environmental aspect.

Introduction of Biomass

Availability merits and demerits-Indian scenario-conversion mechanism- utilization of photo synthesis comparison with other energy.

Thermal Biomass Conversion

Combustion, pyrolysis, Gasification and Liquefaction-Biological Conversion-Methanol, Ethanol Production -Fermentation-Anaerobic Digestion Biodegradation and Biodegradability of Substrate.

Combustion

Perfect, complete and incomplete combustion-stoichiometric air requirement for biofuels -equivalence ratio-fixed bed and fluid Bed combustion-fuel and ash handling systems-steam cost comparison with conventional fuels.

Power Generation Techniques

Through Fermentation and Gasification-Biomass Production from different Organic Wastes-Effect of Additives on Biogas Yield-Biogas production from Dry Dung Cakes-Industrial Application-Viability of Energy Production-Wood Gasifier System, Operation of Spark Ignition and Compression Ignition with Wood Gas Operation and Wood Gas Operation and Maintenance.

Economics and Environmental Aspects

Energy Effectives and Cost Effectiveness-History of Energy Consumption and Cost – Environmental Aspects of Bio-energy Conversion.

REFERENCES

1. David Boyles, Bio Energy Technologies Thermodynamics and Costs, Ellis Hoknood,Chichester,1984.
2. Khandelwal KC, Mahdi SS, Biogas Technology-A Practical Handbook, Tata McGraw Hil,1986.
3. R.C. Maheswari, Bio Energy for Rural Energisation ,Concept Publication,1987.
4. Anthony San Pietro, Biochemical and Photosynthetic aspects of Energy Production, Academic Press, New York,1980.
5. EL-Halwagi MM, Biogas Technology: Transfer & Diffusion, Elsevier Applied SC, London 1986.
6. Tom B Reed, Biomass Gasification-Principles and Technology, Noyce Data Corporation,1981.
7. Iyer PVR et al, Thermochemical Characterization of Biomass, M N E S.

COURSE OUTCOMES

Upon completion of the course, the students will be able to

1. Gain vast idea of the various form of biomass availability in the earth.
2. Get complete understanding of the various biomass energy conversion technologies,
3. Understand the importance of bio mass
4. Learn the chemistry behind the combustion process.
5. Learn the economical and environmental aspects of biomass energy conversion.

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓				✓	✓		✓	
CO2	✓				✓	✓		✓	
CO3	✓				✓	✓		✓	
CO4	✓				✓	✓		✓	
CO5	✓				✓	✓		✓	

✓

MEEMSCN	**BOILER TECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

The course content should be taught with the aim to develop different types of skills so that students are able to acquire following competency:

- To apply basic concepts, laws and principles of Boiler design.
- To impart greater understanding of heat balance in Boiler for modern power plant.
- To throw light on the heat transfer aspects involved in boiler technology.
- To enlighten the students on the various techniques involved in the boiler code.

Introduction

Parameter of a Steam Generator - Thermal Calculations of a Modern Steam Generator - Tube Metal Temperature Calculation and Choice of Materials - Steam Purity Calculations and Water Treatment Heat balance: Heat transfer in Furnace - Furnace Heat Balance - Calculation of Heating Surfaces - Features of Firing Systems for Solid - Liquid and Gaseous Fuels - Design of Burners

Boiler Design

Design of Boiler Drum - Steam Generator Configurations for Industrial Power and Recovery Boilers - Pressure Loss and Circulation in Boilers

Design of Accessories

Design of Air Preheaters - Economisers and Superheater for High Pressure Steam Generators - Design Features of Fuel Firing Systems and Ash Removing Systems

Emission Aspects

Emission Control – Low NOx Burners– Boiler Blow Down - Control & Disposal : Feed Water Deaeration & Deoxygenation – Reverse Osmosis - Ash Handling Systems Design – Ash Disposal– Chimney Design to meet Pollution std – Cooling Water Treatment & Disposal

Boiler code

IBR and International Regulations - ISI Code's Testing and Inspection of Steam Generator - Safety Methods in Boilers - Factor of Safety in the Design of Boiler Drums and Pressure Parts - Safety of Fuel Storage and Handling - Safety Methods for Automatic Operation of Steam Boilers

REFERENCES

1. Prabir Basu, Cen Kefa and Louis Jestin, Boilers and Burners: Design and Theory, Springer, 2000.
2. Ganapathy, V., Industrial Boilers and Heat Recovery Steam Generators, Marcel Dekker Ink, 2003.
3. David Gunn and Robert Horton, Industrial Boilers, Longman Scientific and Technical Publication, 1986.
4. Carl Schields, Boilers: Type, Characteristics and Functions, McGraw Hill Publishers, 1982
5. Howard, J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, NewYork, 1983.
6. Richard Dolezal, Large Boiler Furnaces, Elsevier Publishing Company, 1980 .
7. Power Plant Familiarization NPTI Manual, Govt. of India New Delhi.

COURSE OUTCOMES

At the end of this course, the students will be able to

1. Gain the ability of engineering design calculations in boiler technology.
2. Attain knowledge of modern technology in boiler accessories design and heat balance calculation.
3. Understand the possible emissions from a boiler
4. Understand cooling water treatment method
5. Become excellent managers of the boiler code.

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓	✓				✓			
CO2		✓				✓		✓	
CO3		✓			✓		✓		✓
CO4		✓				✓	✓		
CO5			✓	✓					✓

✓

MEEMSCN	**FLUIDIZED BED SYSTEMS**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

- To understand the design principles and applications of fluidized bed systems.
- To introduce the concepts of fluidization and heat transfer in fluidized beds.
- To introduce the industrial applications of fluidized bed systems

Fluidized Bed Behaviour

Fluidization Phenomena - Regimes of Fluidized Bed Behaviour - Characterization of Fluidized Particles - Two Phase and Well Mixed Theory of Fluidization - Solids Mixing - Particle Entrainment and Carryover.

Heat Transfer

Different Modes of Heat Transfer in Fluidized Bed - Use of Immersed Tubes - Finned Tubes - Heat Recovery Systems.

Combustion and Gasification

Fluidized Bed Combustion and Gasification, Pressurized Systems, Sizing of Combustion and Gasification Systems, Start-up Methods, Fast Fluidized Beds, Different Modes of Heat Transfer in Fluidized Beds.

System Design

Design of Distributors, Fluidized Bed Furnaces for Fossil and Agricultural Fuels, Fluidized Bed Heat Recovery Systems, Fluid Bed Dryers.

Industrial Applications

Sulpher Retention - Nitrogen Emission Control - Furnaces, Dryers, Heat Treatment, etc. Pollution Control and Environmental Effects - Cost Analysis

REFERENCES

1. Howard, J.R., Fluidized Bed Technology: Principles and Applications, Adam Hilger, New York, 1983.
2. Geldart, D, Gas Fluidization Technology, John Wiley & Sons, New York, 1986.
3. Howard, J.R. (Ed), Fluidized Beds : Combustion and Applications, Applied Science Publishers, New York 1983.
4. Yates, J.G. Fundamentals of Fluidized bed Chemical Processes, Butterworths, 1983.
5. Reed, T.B., Biomass Gasification : Principles and Technology, Noyes Data Corporation, New Jersey, 1981.

COURSE OUTCOMES

Upon completion of the course, the students will be able to

1. Understand the working principles, merits and limitations of fluidized bed systems.
2. Understand the various regimes in fluidized bed systems
3. Understand the modes of heat transfer in fluidized bed system
4. Apply fluidized bed systems for a specific engineering application.
5. Analyze the fluidized bed system to improve and optimize its performance.

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓	✓				✓			
CO2	✓	✓				✓	✓		
CO3	✓				✓			✓	
CO4			✓	✓	✓				✓
CO5		✓							✓

✓

MEEMSCN	DESIGN OF HEAT EXCHANGERS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To expose the student to perform the energy transfer analysis on the all types of heat exchangers.
- To impart the knowledge about phase changes-Special application to Condensers and Evaporators.
- To understand and solve the real life industrial problems for heat exchanger design and optimization.

Constructional Details and Heat Transfer

Types - Shell and Tube Heat Exchangers - Regenerators and Recuperators - Industrial Applications Temperature Distribution and its Implications - LMTD - Effectiveness

Flow Distribution and Stress Analysis

Effect of Turbulence - Friction Factor - Pressure Loss - Channel Divergence Stresses in Tubes - Heater Sheets and Pressure Vessels - Thermal Stresses - Shear Stresses - Types of Failures

Design Aspects

Heat Transfer and Pressure Loss - Flow Configuration - Effect of Baffles - Effect of Deviations from Ideality - Design of Typical Liquid - Gas-Gas-Liquid Heat Exchangers

Condensors and Evaporators Design

Design of Surface and Evaporative Condensors - Design of Shell and Tube - Plate Type Evaporators

Cooling Towers

Packings - Spray Design - Selection of Pumps - Fans and Pipes - Testing and Maintenance - Experimental Methods

REFERENCES

1. T. Taborek, G.F. Hewitt and N.Afgan, Heat Exchangers, Theory and Practice, McGraw Hill Book Co., 1980.
2. Walker, Industrial Heat Exchangers - A Basic Guide, McGraw Hill Book Co., 1980.
3. Nicholas Cheremisioff, Cooling Tower, Ann Arbor Science Pub 1981.
4. Arthur P.Fraas, Heat Exchanger Design, John Wiley & Sons, 1988
5. Donald Q Kern, Process Heat Transfer, Tata McGraw Hill, 2008.
6. http ://www.thermomax.com
7. http ://www.tata.com
8. http ://www.altalevel.com

COURSE OUTCOMES

Upon completion of the course, the students will be able to

1. Perform energy transfer analysis in heat exchangers.
2. Learn the types of failures in heat exchangers
3. Able to design condensers and cooling towers
4. The student with engineering equation solver and its use in heat exchanger design.

5. The student to do energy transfer analysis for research and develop energy effective systems.

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓				✓				
CO2		✓					✓		
CO3	✓					✓			
CO4	✓			✓				✓	
CO5			✓						✓

MEEMSCN	**COMPUTATIONAL HEAT TRANSFER**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To impart fundamental mathematical concepts related to computational heat transfer.
- To impart fundamental mathematical concepts about fluid flow and heat transfer.
- To train students in the usage of computational codes and develop new ones.

Mathematical Description of Physical Phenomena

Governing Differential Equation - Energy Equation - Momentum Equation - Nature of Co-ordinates - Discretization Methods

Finite Difference Methods in Partial Differential Equations

Parabolic Equations - Explicit, Implicit and Crank Nicholson Methods. Finite Differences in Cartesian and Polar Co-ordinates. Local Truncation Error - Consistency Convergence - Stability - ADI Methods. Elliptic Equations - Laplace's Equation. Laplace's Equation in a Square - Non-rectangular Regions - Mixed Boundary Condition - Jacobi - Gauss-siedel and SOR Methods. Necessary and Sufficient Conditions for Iterative Methods Finite Difference

Applications in Heat Condition and Convection

Control Volume Approach - Steady and Unsteady One Dimensional Conduction - Two and Three Dimensional Situations - Solution Methodology. Convection and Diffusion: Upwind Scheme - Exponential Scheme. Hybrid Scheme - Power Law Scheme : Calculation of the Flow Field - Simpler Algorithm.

Finite Element Method Concept

General Applicability of the Method using one dimensional heat transfer equation - Approximate Analytical Solution - Raleigh's Method. Galerikin Method, Solution Methods

Finite Element Method Packages

General Procedure - Discretisation of the domain - Interpolation Polynomials - Formulation of Element Characteristic Matrices and Vectors - Direct, Variational and Weighted - Residual Approach - Higher Order Isoparametric Element Formulations Conduction and Diffusion Equations - Heat Transfer Packages - Heat 2, HEATAX, RADIAT, ANSYS

REFERENCES

1. Suhas V.Patnakar, Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation, 1980.
2. Jaluria and Torrance, Computational Heat Transfer - Faluria and Torrance, Hemisphere Publishing Corporation, 1986.
3. A.R.Mitchell and D.F.Grifths, Finite Difference Method in Partial Differential Equations, John Wiley & Sons, 1980
4. S.S.Rao, The Finite Element Methode in Engineering, Pergamon Press - 1989
5. O.C. Zienkiewicz & R.L.Taylor, The Finite Element Method IV Edition - Vol. I & II, McGraw Hill International Edition, 1991
6. www.fluent.com
7. http ://chtol.mech.unsw.edu.au

COURSE OUTCOMES

Upon completion of the course, the students will be able to

1. Acquire fundamental knowledge in mathematical related to computational heat transfer in thermal engineering.
2. Solve problems using mathematical concepts.
3. Solve real world problems using numerical methods.
4. Understand the finite element methods
5. Practice software packages

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓		✓			✓			
CO2		✓						✓	
CO3		✓							✓
CO4	✓	✓	✓	✓					
CO5	✓			✓			✓		

✓

MEEMSCN	**ENERGY STORAGE TECHNOLOGIES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

- Student will be able to demonstrate and apply in depth technical knowledge of engineering in design and operation of various thermal systems.
- Develop the students to enrich their wise through their cognitive skill.
- Student will be able to understand the need for, and an ability to engage in life-long learning and continual updating of professional skills.

Energy Storage Need of energy storage

Different modes of Energy Storage. Potential energy: Pumped hydro storage; KE and Compressed gas system: Flywheel storage, compressed air energy storage; Electrical and magnetic energy storage: Capacitors, electromagnets; Chemical Energy storage: Thermo-chemical, photo-chemical, bio-chemical, electro-chemical, fossil fuels and synthetic fuels. Hydrogen for energy storage.

Electrochemical Energy Storage Systems Batteries

Primary, Secondary, Lithium, Solid-state and molten solvent batteries; Lead Lead acid batteries; Nickel Cadmium Batteries; Advanced Batteries. Role of carbon nano-tubes in electrodes.

Magnetic and Electric Energy Storage Systems

Superconducting Magnet Energy Storage(SMES) systems; Capacitor and Batteries: Comparison and application; Super capacitor: Electrochemical Double Layer Capacitor (EDLC), principle of working, structure, performance and application, role of activated carbon and carbon nano-tube.

Sensible Heat Storage

SHS mediums; Stratified storage systems; Rock-bed storage systems; Thermal storage in buildings; Earth storage; Energy storage in aquifers; Heat storage in SHS systems; Aquifers storage. Solar Ponds for energy storage. Green house heating.

Latent Heat Thermal Energy Storage

Phase Change Materials (PCMs); Selection criteria of PCMs; Stefan problem; Solar thermal LHTES systems; Energy conservation through LHTES systems; LHTES systems in central air-conditioning systems; Energy Storage Food preservation; Waste heat recovery; Solar energy storage;

REFERENCES

1. H.P.Garg et al, D Reidel (1885) "Solar Thermal Energy Storage", Publishing Co.
2. V Alexiades & A.D.Solomon(1993) "Mathematical Modeling of Melting and Freezing Proces" , Hemisphere Publishing Corporation,
3. WashingtonNarayan R, Viswanath B(1998), Chemical and Electro Chemical Energy System, Universities Press
4. A.Ter-Gazarian(1994), "Energy Storage for Power Systems", Peter Peregrinus Ltd.London
5. B.Kilkis and S.Kakac (1989),"Energy Storage Systems",(Ed),KAP,London,1989
6. http ://www.arcon.dk
7. http ://www.tata.com

COURSE OUTCOMES

Upon completion of the course, the students will be able to

1. Understand the principles and technologies for thermal storage system, application and utilization.
2. Identify, formulate and solve simple to complex troubles of thermal storage systems, conversion and storage.
3. Identify and understand principle components and their function.
4. Know the significance of phase change materials
5. Understand the industrial implications of energy storage

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓				✓				
CO2		✓	✓	✓					
CO3	✓							✓	✓
CO4		✓			✓	✓			
CO5		✓		✓					

✓

MEEMSCN	RENEWABLE ENERGY SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To acquire knowledge of technical competency combined with research to generate innovative solutions in Energy engineering.
- To be acquainted with a variety of options in energy sources.
- To prepare the students to exhibit a high level of professionalism, integrity, environmental and social responsibility, and life-long independent learning ability.

Introduction

World energy use-reserves of energy resources-energy cycle of the earth-environmental aspects of energy utilisation-renewable energy resources and their importance.

Solar Energy

Introduction -extraterrestrial solar radiation -radiation at ground level-collectors-solar cells-applications of solar energy- Biomass Energy-Introduction-Biomass Conversion-Biogas Production- Ethanol Production-Pyrolysis and Gasification-Direct Combustion-

Applications

Wind, Geo thermal and Hydro Energy Sources: Introduction-basic theory-types of turbines-applications-Geothermal Energy-Introduction-geothermal resource types-resource base-applications for heating and electricity generation- Hydropower-introduction-basic concepts-site selection-types of turbines-small scale hydropower.

Tidal Energy

Introduction-origin of tides-power generation schemes-Wave Energy-Introduction-basic theory-wave power devices.

Other Renewable Energy Sources: Introduction-Open and Closed OTEC cycles-biophotolysis-Ocean Currents-Salinity Gradient Devices-Environmental Aspects-Potential impacts of harnessing the different renewable energy resources.

REFERENCES

1. A. Duffie and W.A. Beckmann, Solar Engineering of Thermal Processes-John Wiley (1980).
2. F.Kreith and J.F. Kreider, Principles of Solar Engineering, McGraw-Hill (1978).
3. T.N.Veziroglu, Alternative Energy Sources,Vol 5 and 6,McGraw- Hil (1978).
4. http ://www.solstice.crest.orgl
5. http ://www.res-.ltd-com
6. www.mnes.mic.in
7. www.ireada.org

8. http://sundancepower.com

COURSE OUTCOMES

Upon completion of the course, the students will be able to

1. Acquire, apply and share in depth knowledge in the area of Energy Engineering and Management.
2. Conduct independent research and generate knowledge for the benefit of mankind.
3. Apply engineering and scientific principles for the effective management of energy systems.
4. Gain environmental responsibility.
5. Understand the significance of renewable energy systems.

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓			✓		✓			
CO2			✓		✓		✓	✓	
CO3	✓	✓				✓			
CO4	✓							✓	✓
CO5	✓					✓			✓

MEEMSCN	**BIOMASS ENERGY- CONVERSION AND CONSERVATION TECHNIQUES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

- To learn the present biomass energy scenario and the importance of energy conversion.
- To learn the biomass, biomethanation, gasification, pyrolysis and carbonization.
- To analysis different routes of biomass conversion and methods of characterization.

Origin of Biomass

Generation and utilization- Properties of biomass-Agriculture Crop & Forestry residues used as fuels. Biomass: Types – Advantages and drawbacks, Biochemical, Thermo-chemicalConversion- Combustion and Gasification. Biomass gasifiers and types. Applications of Gasifiers to thermal power and Engines.Biomass as a decentralized power generation source for villages Concept of Bio-energy. Characterization of biomass (Proximate analysis and Ultimate analysis) - Indian scenario – Characteristics – Carbon neutrality – Conversion mechanisms – Fuel assessment studies.

Biomass Production and Conversion

Biomass Production: Introduction- Wastelands- Classification and their use through energy plantation- Selection of species-Methods of field preparation and transplanting. Harvesting of biomass. Biomass Conversion: Different routes of conversion of biomass such as Physical: cutting- Sizing, drying and storage of wood- Twigs and other biomass. Biochemical-Conversion of biomass- Sugar- starch and cellulose into alcohol- Biodiesel. Thermo chemical- Direct combustion- improved cookstoves- Briquetting of biomass- pyrolysis- gasification. Biomass Characterizations: Physio-chemical characteristics of biomass- Calorific values of solid- Liquid and Gaseous fuels.

Biomethanation and Combustion

Bio-Chemical Conversion: Aerobic and Anaerobic conversion phases in biomass production- Fermentation etc. Bio-fuels: Importance- Production and applications. Bio-fuels: Types of Bio-fuels, Production processes and technologies - Bio fuel applications- Ethanol as a fuel for I.C. engines. Combustion : Perfect- Complete and incomplete – Equivalence ratio – Fixed Bed, Fluid Bed – Fuel and Ash handling – Steam cost comparison with conventional fuels. Briquetting: Types of Briquetting – Merits and demerits – Feed requirements and preprocessing – Advantages – Drawbacks.

Gasification

Types – Comparison – Application – Performance evaluation – Economics – Dual fuel engines –100 % Gas Engines – Engine characteristics on gas mode – Gas cooling and cleaning train. Gas producer – Types - Operating principle. Gasifier fuels- Properties-preparation-Conditioning of producer gas. Application-Shaft power generation- Thermal application-economics.

Pyrolysis and Carbonization

Plant operation- Product recovery- Incineration and Plant lay out. Types – Process governing parameters – Thermo gravimetric analysis – Differential thermal analysis – Differential scanning calorimetry – Typical yield rates.

REFERENCES

Biomass Renewable Energy – D.O.hall and R.P. Overeed (John Wiley and Sons, New york, 1987).

1. Biomass Gasification Principles and Technology, Energy technology review No. 67, - T.B. Read (Noyes Data Corp. 1981).
2. G.D. Rai. Non-Conventional Energy Sources, Kh Publishers, New Delhi.
3. Rathore N. S., Panwar N. L, Kothari S., Biomass Production and Utilization Technology. Himanshu Production, 2007.
4. Vimal, O. P. and Bhatt, M.S., Wood Energy System, Agricole, Pub. New Delhi.
5. Best Practises Manual for Biomass Briquetting, I R E D A, 1997.
6. David Boyles, Bio Energy Technology Thermodynamics and costs, Ellis Hoknood Chichester, 1984. Khandelwal KC, Mahdi SS, Biogas Technology – A Practical Handbook, Tata McGraw Hill, 1986.

COURSE OUTCOMES

After successful completion of this course, the students should be able to

1. Understand the generation and utilization of various biomass resources.
2. Gain knowledge on proximate and ultimate analysis.
3. Understand the various biomass conversion - biomethanation, gasification and pyrolysis.
4. Learn the environmental impact of bio mass conversion
5. Know the potential of biomass resources

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓				✓				
CO2		✓						✓	
CO3	✓			✓					✓
CO4		✓				✓		✓	
CO5	✓							✓	✓

✓

MEEMSCN	BIOMASS GASIFICATION -TECHNOLOGY AND UTILIZATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To learn about the different types biomass technology.
- To study the origin and developments of gasification system.
- To learn the various types of gasifier, purification, cooling system and impact on environment.
- To learn the properties of gaseous fuel from woody biomass and application as engine fuel.

Introduction

Overview of gasification technology-Biomass as gasification fuel- Gasification for energy supply- Gasification history and development- Gasification process-Producer gas and its constituents-Hazards with producer gas. Suitability of Bio mass fuels: Charcoal-Wood-Sawdust-Peat-Agricultural residues.

Biomass Technology

Biological Conversion- Bioconversion mechanism, sources of wastes undergoing biotreatment, biogas. Energetics and rate processes of major biological significance. Bioconversion of substrates into alcohols, organic acids, solvents, amino acids, antibiotics etc. Thermochemical Conversion: - Conversion to solid, liquid and gaseous fuels. Pyrolysis, gasification, energy balance and the economics.

Gasifiers, Gas Cleaning and Cooling

Gasifiers- Up draught Gasifiers -Down draught Gasifiers -Twin-fire Gasifiers - Cross draft Gasifiers -Fluidized bed gasifiers & Other Gasifiers. Theory of Gasification: Prediction of the gas composition, Gasifier Efficiency. Gas Cleaning and Cooling: Cleaning dust from the gas- Gas cooling. Health and Environmental hazards associated with the use of producer gas: Toxic hazards- Fire hazards- Explosion hazards- Environmental hazards.

Impact of Fuel Properties on Gasification and Drive Engines

Gasification fuels-Need for selection of the right gasifier for each fuel-Energy content of the fuel- Moisture content of the fuel- Voltaile matter content of the fuel-ash content and ash chemical composition-Reactivity of the fuel-Particle size and distribution-Bulk density of the fuel-Charring properties of the fuel- Assessment of the suitability of various types of biomass as gasifier fuel.

Producer gas drive engines- Performance of gasifier- engine system- Operational difference between diesel and gasoline engine- Conversion of gasoline engine to produce gas-Conversion of diesel engine to producer gas- Conditions of producer gas- Engine power output using producer gas- Gas quality requirements for trouble free operation.

Technologies for Biomass Utilisation

Biomass utilisation strategy - Applications to be serviced - Biomass classification and - properties Gasification- Combustion vs Gasification - Woody biomass gasifier (thermal and electric)-Pulverised fuel gasifier (thermal and electric) - Engine operation - Technologies available- Production of fuel gas-production of mechanical or Electrical power in stationary installations.-Mobile applications.

REFERENCES

1. P.F. Stan Bury and A. Witalker, 'Principles of Fermentation Technology, Pergamo Press,1984.
2. H. D. Kumar Biotechnology, 1991.
3. Tom B Reed, Biomass Gasification – Principles and Technology, Noyce Data Corporation, 1981.
4. D.O. Hall, G.N. Barnard, and P.A. Moss, Biomass for Energy in the Developing Countries, Current Roles, Potential, Problems, Prospects, Pergamon, Press Ltd. 1990
5. L.P. White, L.G. Claskett, Biomass as Fuel, Academic Press, 1981
6. T.B. Real, Biomass Gasification Principles and Technology, Energy Technology Review,No.67, Hoyes Data Corporation, U.S.A.1981.
7. Microbial Technology, Fermentation Technology, Edited by Peppler and Perlman, Vol. I and II, Academic Press.

COURSE OUTCOMES

Upon completion of the course, students will be able to

1. Understand biomass gasification technology.
2. Learn different types of gasifier and purification systems.
3. Gain knowledge on different fuel properties
4. Understand the impact of fuels on gasification and engines.
5. Understand the technologies for biomass utilization

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓				✓				
CO2		✓						✓	
CO3	✓			✓					✓
CO4		✓				✓		✓	
CO5	✓							✓	✓

MEEMSCN	**ENERGY AUDITING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To familiarize various forms of energy
- To understand energy management concepts
- To learn the methods of energy audit and usage of instruments
- To analyze and report the outcome of energy audit

Fundamentals of Energy

Basics of energy and its various forms: Conventional and non -conventional sources. Different fuels and its energy contents. Renewable energy - solar energy, wind energy, bio energy, hydro energy, geothermal energy, wave energy, tidal energy and OTEC.

Energy Management

Energy management- various approaches, cost effectiveness, bench marking, optimization of energy requirement and maximization of system efficiencies. Fuels and energy substitution.

Energy Audit
Energy audit – need, preliminary audit, detailed audit, methodology and approach. Instruments for audit, monitoring energy and energy savings.

Assessment and Reporting
Evaluation of saving opportunities – determining the savings in INR, non- economic factors, conservation opportunities, estimating cost of implementation.

Energy Audit Reporting the plant energy study report, importance, effective organization, report writing and presentation.

REFERENCES

1. Energy Management Audit & Conservation by Barun Kumar De Publisher: Vrinda Publications 2007
2. Hamies, Energy Auditing and Conservation: Methods, Measurements, Management & Case Study, Hemisphere, Washington, 1980.
3. Energy Management: W.R.Murphy, G.Mckay (Butterworths).
4. Energy Management Principles: C.B.Smith (Pergamon Press)
5. Efficient Use of Energy: I.G.C.Dryden (Butterworth Scientific)
6. Energy Economics -A.V.Desai (Wieley Eastern)

COURSE OUTCOMES
Upon completion of the course, students will be able to

1. Understand various energy management concepts
2. Learn the methods of energy audit and usage of instruments
3. Analyze and report the outcome of energy audit
4. Become a potential energy auditor
5. Promote lifelong learning

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓					✓			
CO2	✓			✓		✓			
CO3		✓		✓				✓	
CO4		✓	✓	✓					✓
CO5	✓	✓	✓	✓	✓	✓	✓	✓	✓

✓

MEEMSCN	**WASTE MANAGEMENT AND ENERGY GENERATION TECHNIQUES**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES

- To familiarize students with recent energy generation techniques
- To provide information on various methods of waste management
- To detail on the recent technologies of waste disposal and
- To make student realize on the importance of healthy environment

Solid Waste

Definitions - Sources, Types, Compositions, Properties of Solid Waste - Municipal Solid Waste - Physical, Chemical and Biological Property - Collection - Transfer Stations - Waste Minimization and Recycling of Municipal Waste

Waste Treatment

Size Reduction - Aerobic Composting - Incineration - Furnace Type & Design, Medical / Pharmaceutical waste Incineration -Environmental Impacts - Measures to Mitigate Environmental effects due to Incineration.

Waste Disposal

Land Fill Method of Solid Waste Disposal - Land Fill Classification, Types, Methods & Siting Consideration - Layout & Preliminary Design of Land Fills - Composition, Characteristics, generation, Movement and Control of Landfill Leachate & Gases- Environmental Monitoring System for Land Fill Gases

Hazardous Waste Management

Definition & Identification of Hazardous Waste - Sources and Nature of Hazardous Waste - Impact on Environment - Hazardous Waste Control - Minimization and Recycling - Assessment of Hazardous Waste Sites - Disposal of Hazardous Waste, Underground Storage Tanks Construction, Installation & Closure Energy Generation from Waste: Types - Biochemical Conversion - Sources of Energy Generation - Industrial Waste, Agro Residues.

Anaerobic Digestion

Biogas Production - Types of Biogas Plant Thermochemical Conversion - Sources of Energy Generation - Gasification - Types of Gasifiers - Briquetting - Industrial Applications of Gasifiers - Utilization and Advantages of Briquetting - Environmental Benefits of Biochemical and Thermochemical Conversion

REFERENCES

1. Parker, Colin, & Roberts, Energy from Waste - An Evaluation of Conversion Technologies, Elsevier Applied Science, London, 1985
2. Shah, Kanti L., Basics of Solid & Hazardous Waste Management Technology, Prentice Hall, 2000.
3. Manoj Datta, Waste Disposal in Engineered Landfills, Narosa Publishing House, 1997
4. Rich, Gerald et.al., Hazardous Waste Management Technology, Podvan Publishers, 1987
5. Bhide AD., Sundaresan BB, Solid Waste Management in Developing Countries, INSDOC New Delhi, 1983

COURSE OUTCOMES

Upon completion of the course, the students will be able to

1. Understand the waste characterization, segregation and disposal
2. Familiarize the technologies that are available for effective waste disposal
3. Understand the problem in a sensible and realistic manner
4. Learn the principles of hazardous waste treatment
5. Understand the environmental benefits of biochemical and thermochemcial conversions

Mapping of COs with POs									
COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**
CO1	✓				✓				
CO2		✓		✓		✓			
CO3		✓				✓		✓	✓
CO4		✓				✓		✓	✓
CO5	✓	✓							

✓

OPEN ELECTIVES

MEEMOESCN	**NUCLEAR ENGINEERING**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

COURSE OBJECTIVES:

- To learn the basics of nuclear engineering
- To know the reactor kinetics
- To prepare the students to exhibit a high level of professionalism, integrity, environmental and social responsibility, and life-long independent learning ability

Basics of nuclear fission and power from fission
Radioactivity, nuclear reactions, cross sections, nuclear fission, power from fission, conversion and breeding

Neutron transport and diffusion
Neutron transport equation, diffusion theory approximation, Fick's law, solutions to diffusion equation for point source, planar source, etc., energy loss in elastic collisions,neutron slowing down

Multigroup, multiregion diffusion equation, concept of criticality
Solution of multigroup diffusion equations in one region and multiregion reactors, concept of criticality of thermal reactors

Reactor kinetics and control
Derivation of point kinetics equations, inhour equation, solutions for simple cases of reactivity additions, fission product poison, reactivity coefficients

Heat removal from reactor core
Solution of heat transfer equation in reactor core, temperature distribution, critical heat flux
Reactor safety, radiation protection
Reactor safety philosophy, defence in depth, units of radioactivity exposure, radiation protection standards

REFERENCES:

1. Introduction to Nuclear Engineering (3rd Edition) by John R. Lamarsh, Anthony J.Barrata, Prentice Hall, (2001)
2. Introduction to Nuclear Reactor Theory, by John R. Lamarsh, Addison-Wesley, 1966)
3. Nuclear Reactor Analysis, by James J. Duderstadt and Lewis J. Hamilton, John Wiley(1976)

COURSE OUTCOMES:

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

1. Understand the basic concepts and processes taking place inside a nuclear reactor
2. Understand the techniques of neutron production, scattering, diffusion, slowing down and absorption.
3. Familiar with concepts of reactor criticality, the relationship between the dimension and fissile material concentration in a critical geometry.
4. Familiar with time dependent (transient) behaviour of power reactor in non-steady state operation and the means to control the reactor.
5. Familiar with the concepts of heat removal from reactor core, reactor safety and radiation protection.

MEEMOESCN	FUELS AND COMBUSTION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To learn different type of conventional and non conventional fuel with their properties, methods to analysis of fuel, Energy conversion techniques in detail.
- To learn the combustion process of conventional and non conventional fuels, able to calculate the necessary air requirement for combustion process.
- To acquire knowledge in the areas of ignition, Flame study and details of burners to develop combustion process.

Introduction

General, Conventional Energy Sources, Solar Energy, Nuclear Power, Energy from Biomass, Wind Power, Tidal Power, Geothermal Energy, Energy Survey of India, Rocket Fuels,

Solid & Liquid Fuels

General, Family of Coal, Origin of Coal, Gasification of Coal, Analysis and Properties of Coal, Classification of Coal, Oxidation of Coal, Hydrogenation of Coal, Efficient use of Solid Fuel. Renewable Solid (biomass) Fuel, Solid Fuel Handling and Storage. Origin and Classification of Petroleum, Refining and Other Conversion Processes, Composition of Petroleum with respect to Combustion, Property & Testing of Petroleum Products, Various Petroleum Products, Liquid Fuels from Other Sources, Storage and Handling of Liquid Fuels, Liquid Fuels Combustion Equipment

Gaseous Fuels

Types of Gaseous Fuels, Natural Gases, Methane from Coal Mines, Manufactured Gases, Producer Gas, Water Gas, Carburetted Water Gas, Blast Furnace Gas, Biogas, Refinery Gas, LPG, Cleaning and Purification of Gaseous Fuels.

Theory of Combustion Process and Stoichiometry

Combustion Thermodynamics, Stoichiometry Relations, Rapid Methods of Combustion Stoichiometry, Theoretical Air Required for Complete Combustion, Mass Basis and Volume Basis Calculation of Minimum Amount of Air Required for a Fuel of known Composition, Calculation of Dry Flue Gases if Fuel Composition is Known, Calculation of the Composition of Fuel, Excess Air Supplied and Amount of Exhaust gases.

Burner Design

Ignition, Concept of Ignition, Auto Ignition, Ignition Temperature, Flame, Flame Propagation, Flame Front, Various Methods of Flame Stabilization, Concepts of Burner, Basic Features and Types of Solid, Liquid and Gaseous Fuel Burners - Different Types of Coal - Oil and Gas Burners, Recuperative & Regenerative Burners.

REFERENCES

1. Samir Sarkar, Fuels & Combustion, 2nd Edition, Orient Longman, 1990
2. Bhatt ,vora Stoichiometry, 2nd Edition, Tata Mcgraw Hill, 1984
3. Blokh AG, Heat Transfer in Steam Boiler Furnace, Hemisphere Publishing Corpn, 1988
4. Civil Davies, Calculations in Furnace Technology, Pergamon Press, Oxford, 1966
5. Sharma SP, Mohan Chander, Fuels & Combustion, Tata Mcgraw Hill, 1984 EIA

COURSE OUTCOMES

Upon completion of the course, students will be able to

1. Evaluate the properties of conventional and non conventional fuel, and to describe, compare, cost and availability.
2. Learn the various advantages and disadvantages of each fuel.
3. Understand the complete combustion process of each fuel,
4. Able to calculate the stoichiometry, theoretical and actual air requirement for the combustion process.
5. Understand the concepts of ignition characteristics, Flame, Flame propagation and Flame front in detail.

MEEMOESCN	NUMERICAL ANALYSIS IN ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To understand the significance of numerical analysis in solving engineering problems.
- To understand the basic concepts of mathematical modeling.
- To promote lifelong learning

Functional Approximation

Interpolation - divided difference, finite difference, Lagrangian, Chebychev, Hermite, Spline interpolations. Least squares methods - Orthogonal polynomial approximations, fourier approximations, fast fourier transforms. Types of errors - introduction to error analysis.

Numerical Calculus

Numerical differentiation. Numerical integration - Newton Cote's formulas, Gaussian quadrature formulas, adaptive quadrature. Solution of a system of linear equations - Gaussian elimination, Crout's method, Cholesky's method, Potter's, iterative methods.

Eigen value problems

Power and inverse power methods, Householder method, simultaneous iteration method, Lanczo's method.

Solution of Differential Equations

Initial Value problems - Euler's method, Runge-Kutta methods, Variable step methods. Boundary value problems - shooting method.

Unconstrained Optimisation

Single variable minimization, multivariate minimization - direct search methods, gradient Introduction to constrained optimisation.

REFERENCES

1. Ralston and Rabinouitz.P, "A first course in Numerical Analysis", McGraw Hill, 1978.
2. Hildebrand F.B., "Introduction to Numerical Analysis", Tata McGraw Hill, 1974.
3. Mathews, "Numerical Methods in Engineering and Science", PHI, 1995.
4. Rao S.S., "Optimization Techniques", Wiley Eastern 1984.
5. Buchanan & Turner, "Numerical Methods and Analysis", McGraw Hill, 1992.
6. Ramamurthy. V., "Computer Aided Mechanical Design and Analysis", Tata McGraw Hill, 1992.

COURSE OUTCOMES

Upon completion of the course, the students will be able to

1. Understand the common numerical methods used in engineering analysis
2. Estimate the amount of error inherent in different numerical methods.
3. Solve differential equations
4. Assess the efficiency of a selected numerical method when more than one option is available to solve a certain class of problem.
5. Apply these principles for a lifelong learning

MEEMOESCN	ENERGY MANAGEMENT IN BUILDINGS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To learn the green buildings concepts applicable to modern buildings.
- Acquaint students with the principle theories materials, construction techniques and to create energy efficient buildings.
- To learn the methodology of heat transmission in buildings

Introduction

Conventional versus Energy Efficient buildings – Historical perspective - Water – Energy – IAQ requirement analysis – Future building design aspects – Criticality of resources and needs of modern living

Landscape and Building Envelopes

Energy efficient Landscape design - Micro-climates – various methods – Shading, water bodies- Building envelope: Building materials, Envelope heat loss and heat gain and its evaluation, paints, Insulation, Design methods and tools.

Heat Transmission in Buildings

Surface co-efficient- air cavity, internal and external surfaces, overall thermal transmittance, wall and windows; Heat transfer due to ventilation/infiltration, internal heat transfer; Solar temperature; Decrement factor; Phase lag. Design of daylighting; Estimation of building loads: Steady state

method, network method, numerical method, correlations; Computer packages for carrying out thermal design of buildings and predicting performance.

Passive Cooling

Passive cooling concepts- Evaporative cooling, radiative cooling; Application of wind, water and earth for cooling; Shading, paints and cavity walls for cooling; Roof radiation traps; Earth airtunnel. Hybrid methods.

Renewable Energy in Buildings

Introduction of renewable sources in buildings, Solar water heating, small wind turbines, stand-alone PV systems, Hybrid system – Economics.

REFERENCES

1. Krieder, J and Rabi, A., Heating and Cooling of buildings : Design for Efficiency, Mc Graw Hill, 1994.
2. Ursala Eicker, "Solar Technologies for buildings", Wiley publications, 2003.
3. Guide book for National Certification Examination for Energy Managers and Energy Auditors
4. Smith, CB Energy Management Principles, Pergamon Press, NewYork, 1981.

COURSE OUTCOMES

Upon completion of the course, the student will be able to

1. Learn the critical resources required for a modern living
2. Perform energy audit in any type for buildings and suggest the conservation measures.
3. Implement passive cooling techniques in buildings
4. Provide the renewable energy systems for the buildings
5. Enhance their standard of living

MEEMOESCN	ADVANCED POWER PLANT ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES

- To understand and analyze the present and future energy demand of world and nation and techniques
- To exploit the available renewable energy resources such as, solar, bio-fuels, wind power, tidal and geothermal effectively
- To learn advanced topics in power plant engineering

Direct Energy Conversion

Principles and operation of MHD – Design length of channel – Hall effect – Types of MHD generators – Applications of MHD – Principles of EHD and operation – Fuel cells – Principles of Hydrogen – Oxygen fuel cell – Hydro-carbon fuel cells – Redox fuel cell – Lithium Hydrogen fuel cells.

Power Plants

Design of coal bunkers – Co-generation – combined gas and steam power plants – Advantages of Combined cycles – Binary Vapour cycles.

Solar Energy

Storage – Stratified storage – Well mixed storage – Comparison – Solar ponds – types – Description of Non-Convective solar pond – Extraction of Thermal energy – Application of solar pond. Solar Electric Power Generation – Tower concept – Photovoltaic cells – Design of swimming pool heaters & Power generation systems – Utilisation of bio-mass – Combustion – Pyrolysis- Gasification – Design of Gasifier – Heat and power generation applying bio-mass.

Other Non-Conventional Energy Systems

Geo-thermal energy – Different types of geothermal energy systems – Economic justification – OTEC power plants – Types & working principle.

Tidal Power Plants

Types – Working principle – Advantages & Disadvantages – Bio-gas generation and uses. Wind energy – Different types of wind power plants – problems on wind turbines – Advantages and disadvantages.

REFERENCES

1. Soo S.L., Direct Energy Conversion, 1965.
2. Rai G.D., Solar Energy Utilisation, Khanna Publishers, New Delhi, 1998.
3. Suhatme S.P., Solar Energy – Principles of Thermal Collection & Storage, Tata McGraw Hill
4. Elwakil M, Power Plant Technology, McGraw Hill, New York, 1964.
5. Archie W. Culp. Jr., Principles of Energy Conversion, McGraw Hill, 1968.
6. Kreider J.M. and Krieth J.F., Principles of Solar Engineering, McGraw Hill, New York, 1972.
7. Peter J.Lunde, Solar Thermal Engineering, John Wiley & Sons, New York, 1978.

COURSE OUTCOMES

Upon the completion of the course, the students will be able to

1. Acquire fundamental knowledge in energy generation, heat transfer and to utilization
2. Gain basic knowledge in renewable energy conversion technology
3. Learn the various cycles employed in power plants
4. Ability to use modern engineering tools, software and equipment to analyze and solve complex engineering problems.
5. Solve real world problems and reduce the impact global warming for betterment of living things to serve healthy life.

AUDIT COURSES

MEEMACSCN	ENGLISH FOR RESEARCH PAPER WRITING	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

Students will be able to:

- Understand that how to improve your writing skills and level of readability
- Learn about what to write in each section
- Understand the skills needed when writing a title
- Ensure the good quality of paper at very first-time submission

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts. Introduction

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check.

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,

Kkills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission

REFERENCES

1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book .
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011.

MEEMACSCN	DISASTER MANAGEMENT	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

Students will be able to:

- Learn to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Critically evaluate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Develop an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.

- Critically understand the strengths and weaknesses of disaster management approaches, planning and programming in different countries, particularly their home country or the countries they work in

Introduction Disaster: Definition, Factors And Significance; Difference Between Hazard And Disaster; Natural And Manmade Disasters: Difference, Nature, Types And Magnitude.

Repercussions of Disasters And Hazards: Economic Damage, Loss of Human And Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster:
Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks of Disease And Epidemics, War And Conflicts.

Disaster Prone Areas In India: Study Of Seismic Zones; Areas Prone To Floods And Droughts, Landslides And Avalanches; Areas Prone To Cyclonic And Coastal Hazards With Special Reference To Tsunami; Post-Disaster Diseases And Epidemics

Disaster Preparedness and Management: Preparedness: monitoring of phenomena triggering a disaster or hazard; evaluation of risk: application of remote sensing, data from meteorological and other agencies, media reports: governmental and community preparedness.

Risk Assessment: Disaster Risk: Concept And Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation In Risk Assessment And Warning, People's Participation in Risk Assessment. Strategies for Survival.

Disaster Mitigation: Meaning, Concept And Strategies Of Disaster Mitigation, Emerging Trends In Mitigation. Structural Mitigation And Non-Structural Mitigation, Programs Of
Disaster Mitigation in India.

REFERENCES

1. R. Nishith, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company.
2. Sahni, Pardeep Et.Al. (Eds.)," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi.
3. Goel S. L. , Disaster Administration And Management Text And Case Studies" ,Deep &Deep Publication Pvt. Ltd., New Delhi.

MEEMACSCN	SANSKRIT FOR TECHNICAL KNOWLEDGE	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

- To get a working knowledge in illustrious Sanskrit, the scientific language in the world
- Learning of Sanskrit to improve brain functioning
- Learning of Sanskrit to develop the logic in mathematics, science & other subjects Enhancing the memory power
- The engineering scholars equipped with Sanskrit will be able to explore the huge knowledge from ancient literature

Alphabets in Sanskrit, Past/Present/Future Tense, Simple Sentences, Order, Introduction of roots, Technical information about Sanskrit Literature, Technical concepts of Engineering - Electrical, Mechanical, Architecture, Mathematics

REFERENCES

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi.

COURSE OUTCOMES

Upon successful completion of the course, the students are able to:

1. Understanding basic Sanskrit language
2. Ancient Sanskrit literature about science & technology can be understood
3. Being a logical language will help to develop logic in students.

MEEMACSCN	VALUE EDUCATION	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

Students will be able to

- Understand value of education and self- development
- Imbibe good values in students
- Let the should know about the importance of character

Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non- moral valuation. Standards and principles. Value judgements

Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism.Love for nature ,Discipline

Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour. Universal brotherhood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

Character and Competence –Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence ,Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively.

REFERENCES

1. Chakroborty, S.K. "Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

COURSE OUTCOMES

Upon successful completion of the course, the students are able to:

1. Knowledge of self-development
2. Learn the importance of Human values
3. Developing the overall personality.

MEEMACSCN	CONSTITUTION OF INDIA	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional role and entitlement to civil and economic rights as well as the emergence of nationhood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik
- Revolution in 1917 and its impact on the initial drafting of the Indian Constitution.

History of Making of the Indian Constitution: History Drafting Committee, (Composition & Working)

Philosophy of the Indian Constitution: Preamble Salient Features

Contours of Constitutional Rights & Duties: Fundamental Rights, Right to Equality Right to Freedom Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

Organs of Governance: Parliament, Composition, Qualifications and Disqualifications Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions

Local Administration: District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO of Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level: Role of Elected and Appointed officials, Importance of grass root democracy

Election Commission: Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners. State Election Commission: Role and Functioning. Institute and Bodies for the welfare of SC/ST/OBC and women.

REFERENCES

1. The Constitution of India, 1950 (Bare Act), Government Publication.
2. Dr. S. N. Busi, Dr. B. R. Ambedkar framing of Indian Constitution, 1st Edition, 2015.
3. M. P. Jain, Indian Constitution Law, 7th Edn., Lexis Nexis, 2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

COURSE OUTCOMES

Upon successful completion of the course, the students are able to:

1. Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
2. Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.

3. Discuss the circumstances surrounding the foundation of the Congress Socialist Party [CSP]under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
4. Discuss the passage of the Hindu Code Bill of 1956.

MEEMACSCN	PEDAGOGY STUDIES	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

Students will be able to:

- Review existing evidence on the review topic to inform programme design and policy making undertaken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

Introduction and Methodology: Aims and rationale, Policy background, Conceptual framework and terminology, Theories of learning, Curriculum, Teacher education. Conceptual framework, Research questions**.** Overview of methodology and Searching.

Thematic overview: Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries. Curriculum, Teacher education.

Evidence on the effectiveness of pedagogical practices Methodology for the in depth stage: quality assessment of included studies. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? Theory of change. Strength and nature of the body of evidence for effective pedagogical practices. Pedagogic theory and pedagogical approaches. Teachers' attitudes and beliefs and Pedagogic strategies.

Professional development: alignment with classroom practices and follow- up support Peer support Support from the head teacher and the community. Curriculum and assessment Barriers to learning: limited resources and large class sizes

Research gaps and future directions: Research design, Contexts, Pedagogy, Teacher education, Curriculum and assessment, Dissemination and research impact.

REFERENCES

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31 (2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36 (3): 361-379.
3. Akyeampong K (2003) Teacher training in Ghana - does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33 (3): 272–282.
5. Alexander RJ (2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M (2003) Read India: A mass scale, rapid, 'learning to read' campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf.

COURSE OUTCOMES

Upon successful completion of the course, the students are able to:

1. What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
2. What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
3. How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

MEEMACSCN	STRESS MANAGEMENT BY YOGA	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

- To achieve overall health of body and mind
- To overcome stress

Definitions of Eight parts of yog. (Ashtanga) Yam and Niyam.
Do`s and Don't's in life.

(i) Ahinsa, satya, astheya, bramhacharya and aparigraha
(ii) Shaucha, santosh, tapa, swadhyay, ishwarpranidhan

Asan and Pranayam

(i) Various yog poses and their benefits for mind & body
(ii) Regularization of breathing techniques and its effects-Types of pranayama

REFERENCES

1. 'Yogic Asanas for Group Tarining-Part-I" : Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

COURSE OUTCOMES

Upon successful completion of the course, the students are able to:

1. Develop healthy mind in a healthy body thus improving social health also
2. Improve efficiency

MEEMACSCN	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	L	T	P	C
		2	0	0	0

COURSE OBJECTIVES

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To awaken wisdom in students

Neetisatakam-Holistic development of personality

- Verses- 19,20,21,22 (wisdom)
- Verses- 29,31,32 (pride & heroism)
- Verses- 26,28,63,65 (virtue)
- Verses- 52,53,59 (dont's)
- Verses- 71,73,75,78 (do's)

Approach to day to day work and duties.
Shrimad Bhagwad Geeta :

- Chapter 2-Verses 41, 47,48,
- Chapter 3-Verses 13, 21, 27, 35,
- Chapter 6-Verses 5,13,17,23, 35,
- Chapter 18-Verses 45, 46, 48.

Statements of basic knowledge.
Shrimad Bhagwad Geeta:

- Chapter2-Verses 56, 62, 68
- Chapter 12 -Verses 13, 14, 15, 16,17, 18

Personality of Role model.
Shrimad Bhagwad Geeta:

- Chapter2-Verses 17,
- Chapter 3-Verses 36,37,42,
- Chapter 4-Verses 18, 38,39
- Chapter18 – Verses 37,38,63

REFERENCES

1. "Srimad Bhagavad Gita" by Swami Swarupananda Advaita Ashram (Publication Department), Kolkata
2. Bhartrihari's Three Satakam (Niti-sringar-vairagya) by P.Gopinath, Rashtriya Sanskrit Sansthanam, New Delhi.

COURSE OUTCOMES

Upon successful completion of the course, the students are able to:

1. Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
2. The person who has studied Geeta will lead the nation and mankind to peace and prosperity
3. Study of Neetishatakam will help in developing versatile personality of students.