DEPARTENT OF MECHANICAL ENGINEERING

LIST OF COURSES OFFERED FOR HONOR PROGRAM (R20)

Course code	Course Title	Contact hours/week				Credits
		L	T	P	**Total**	
20MEH1	Advanced Thermodynamics	3	1	0	4	4
20MEH2	Fuel Cell Technology	3	1	0	4	4
20MEH3	Hybrid & Electrical Vehicles	3	1	0	4	4
20MEH4	Energy Storage System	3	1	0	4	4

L	T	P	Cr.
3	1	0	4

B.Tech. (Sem.) **20MEH1-ADVANCED THERMODYNAMICS**

Pre-requisites: Thermodynamics.

Course Educational Objective:

The present course on Advanced Engineering Thermodynamics deals with review on laws of thermodynamics, thermodynamics relations, exergy involvement in thermal systems, reactive mixtures, and propulsion systems.

Course Outcomes (COs): At the end of the course, the student will be able to

CO1: Distinguish the laws of thermodynamics applied to thermal systems. (**Understanding –L2**).

CO2: Apply the thermodynamics laws to solve various thermal system problems. (**Applying -L3**).

CO3: Analyse the thermodynamic properties of various thermal systems. (**Analysing -L4**).

CO4: Compare the exergy and irreversibility of closed and open thermal systems. (**Analysing -L4**).

CO5: Describe the working of advanced power cycles. (**Understanding–L2**).

UNIT - I

THERMODYNAMICS – Introduction, Review of Zeroth, First, Second and third law of thermodynamics.

THERMODYNAMIC RELATIONS: Introduction – Reciprocity and cyclic relations – The Maxwell's relations – The Gibbs and Helmholtz relations - The Clapeyron Equation, General relations for du, dh, ds - Co-efficient of volumetric expansion -Isothermal compressibility.

UNIT- II

KINETIC THEORY OF GASES: Kinetic theory of gases- introduction, basic assumptions, mean free path, molecular flux, collisions with a moving wall,-intermolecular forces, The Vander Waals equation of state.

UNIT- III

NON REACTIVE MIXTURES: Review of basic thermodynamics of ideal gas mixtures, Stoichiometry, Fundamentals of combustion kinetics, General characteristics of combustion flame and detonation

REACTIVE GAS MIXTURES: Introduction- Fuels and Combustion-theoretical and actual combustion processes- Enthalpy of formation and Enthalpy of reaction- First and Second law analysis of reacting systems- Applications.

UNIT – IV

EXERGY AND IRREVERSIBILITY: Introduction - Availability of heat - Availability of a closed system - Availability of open system - Applications. Irreversibility for closed and open system – Effectiveness-Applications.

UNIT – V

ADVANCED POWER CYCLES: Atkinson cycle, Lenoir cycle, second law analysis of vapour and gas power cycles, Working of Binary vapour, Cogeneration, and combined gas power cycles-Applications.

TEXTBOOKS

1. Sonntag, Borgnakke, Van Wyllan, Fundamentals of Thermodynamics: 5th Edition John Wiley and Sons, 2010.
2. P.K.Nag, Engineering Thermodynamics: 4th Edition 2008, TMH.

REFERENCES

1. YunusA.Cengel& Michael Boles, Thermodynamics (An Engineering Approach) 7th Edition 2011, TMH.
2. E.Rathakrishnan, Fundamentals of Engineering Thermodynamics 2nd Edition, EEE, PHI Publishers, 2010.
3. J.P.Holman, Thermodynamics, 9th Edition, 2012, TMH.

L	T	P	Cr.
3	1	0	4

B.Tech. (Sem.) **20MEH2-FUEL CELL TECHNOLOGY**

Pre-requisites: Thermodynamics and Chemistry

Course Educational Objective:

To know details of fuel cell technology, in particular the opportunities for using hydrogen

Course Outcomes: After the completion of the course students are able to

CO1: Describe the hydrogen energy storage system and its applications. (**Understanding - L2**).

CO2: Understand the production techniques of hydrogen. (**Understanding - L2**).

CO3: Comprehend the hydrogen storage and transport systems. (**Understanding - L2**).

CO4: Compare the performance characteristics of different fuel cells. **(Analysing –L4)**

CO5: Compute the power generation capacity of a fuel cell. (**Applying –L3**)

UNIT - I

HYDROGEN ENERGY ECONOMY: Hydrogen Energy Economy – Conception, Present status and a vision – Applications of Hydrogen - Transport application-cars, light trucks, buses - Stationary and Portable Electronic gadgets.

UNIT - II

HYDROGEN PRODUCTION TECHNIQUES: Hydrogen – Physical and chemical properties, salient characteristics - Production of hydrogen – Steam reforming – Water electrolysis – Gasification and woody biomass conversion – Biological hydrogen production – Photo dissociation – Direct thermal or catalytic splitting of water

UNIT - III

HYDROGEN STORAGE: Hydrogen storage options – Compressed gas – Liquid hydrogen method– Hydride storage method– Chemical Storage – Comparisons.

HYDROGEN TRANSPORT: Introduction basic Components, Types of transport system, Applications, Transport of Hydrogen - Pipelines, gaseous, liquid and compound materials.

UNIT - IV

FUEL CELLS: History – Principle - Working - Thermodynamics and kinetics of fuel cell process – Types of fuel cells – AFC, PAFC, SOFC, MCFC, DMFC, PEMFC – Relative merits and demerits - Performance evaluation of fuel cell – Comparison of battery Vs fuel cell – Flow Battery.

UNIT - V

APPLICATION OF FUEL CELL: Fuel cell usage for domestic power systems - Large scale power generation – Automobile - Space - Environmental analysis of usage of Hydrogen in Fuel cell - Future trends in fuel cells.

TEXT BOOKS:

1. Hydrogen and Fuel Cells: A Comprehensive Guide, Rebecca L. and Busby, Penn Well Corporation, Oklahoma (2005).
2. Fuel Cells – Principles and Applications, Viswanathan, B and M Aulice Scibioh, Universities Press (2006).

REFERENCE BOOKS:

1. Hydrogen and Fuel Cells: A Comprehensive Guide, Rebecca L. and Busby, Penn Well Corporation, Oklahoma (2005).
2. Hydrogen and Fuel Cells: Emerging Technologies and Applications, Bent Sorensen (Sørensen), Elsevier, UK (2005).
3. Fuel Cell and Their Applications, Kordesch, K and G.Simader, Wiley-Vch, Germany (1996).
4. Fuel Cells: Theory and Application, Hart, A.B and G.J.Womack, Prentice Hall, NewYork Ltd., London (1989).
5. The Hydrogen Economy, Jeremy Rifkin, Penguin Group, USA (2002).

B.Tech. (Sem.)	20MEH3-HYBRID ELECTRIC VEHICLES	L	T	P	Cr.
		3	1	0	4

Pre-requisites: Internal-Combustion engines.

Course Educational Objective:

The main objective of this course is to provide the knowledge on architecture of Hybrid Electric Vehicles, Fuel cells and their sub-systems. The focus is as well on explaining the requirements of hybrid electric vehicles and Fuel-cells for automobile applications. At the same time, various design considerations in fuel cell vehicles and electric vehicles will be explained.

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

CO1: Compare and contrast the working of Conventional and Electric Vehicles. **(Understanding-L2)**

CO2: Comprehend the use of Series and Hybrid Electric vehicle drive trains. **(Understanding-L2)**

CO3: Apply the fundamentals of to develop the propulsion and storage systems for Hybrid Electric Vehicles. **(Applying-L3)**

CO4: Perform a case study on Hybrid Electric vehicle drive trains for different parameters. **(Analyzing-L4)**

CO5: Describe the working principle of various types of fuel-cells. **(Understanding-L2)**

UNIT-I

ELECTRIC VEHICLES: Introduction, Electric Vehicle Principle- Components of Electric Vehicle Constituents of a conventional vehicle-Drive cycles and Drive Terrain, Operating principle of Fuel Cell, Differences between conventional battery and Electric battery, Transmission differences between conventional and Electric Vehicles, Differences between conventional lighting system and Electric vehicle lighting system.

UNIT-II

HYBRID ELECTRIC VEHICLES: Introduction, A Brief history of Hybrid Electric vehicles (HEVs),Basics of Hybrid Electric Vehicles (HEVs), Architecture of HEVs- Series HEVs, Parallel HEVs, Series-Parallel HEVs.

HYBRID ELECTRIC VEHICLE DRIVE TRAINS: Parallel Hybrid Drive trains with Torque coupling, Parallel Hybrid Drive trains with both Speed coupling, Parallel Hybrid Drive trains with both speed Torque coupling.

UNIT-III

ELECTRIC PROPULSION SYSTEMS: DC Motors- Operating principle and control of DC motors, Induction Motor Drives: Operating principle and Control Mechanisms, Brushless Motor Drives-Principle and Construction, Switched Reluctance Motor (SRM) Drives- Basic structure, Drive Convertor, Modes of Operation.

ENERGY STORAGE SYSTEMS: Electrochemical Batteries, Lead-Acid Batteries, Nickel Based Batteries, Lithium Based Batteries, Ultra Capacitors- Basic Principles and Performance, Ultrahigh-speed flywheels- Basic Principle and Power Capacity, Fly Wheel technologies.

UNIT-IV

DESIGN OF SERIES HYBRID ELECTRIC VEHICLE DRIVES: Design of Series Hybrid Electric Vehicle Drive- Control Strategies, Sizing of Major Components and Case Study for designing for various parameters.

DESIGN OF PARALLEL HYBRID ELECTRIC VEHICLE DRIVES: Design of Parallel Hybrid Electric Vehicle Drive- Control Strategies of Drive Train and Design of Drive Train Parameters.

UNIT-V

FUEL CELL ELECTRIC VEHICLES: Operating principles of fuel cells, Fuel and oxidant consumption, Fuel cell system characteristics, Fuel cell technologies- Proton Exchange membrane fuel cells, Alkaline Fuel cells, Phosphoric acid fuel cells, Molten carbonate fuel cells, Solid oxide fuel cells, Fuel supply- Hydrogen storage-Hydrogen production, Ammonia as hydrogen carrier, Non-Hydrogen fuel cells, Fuel Cell Hybrid Vehicle Drive Train.

TEXT BOOKS

1) Mehrdad Ehsani, Yimin Gao, Ali Emadi, 2nd edition, Modern Electric, Hybrid Electric and Fuel cell vehicles, CRC Press, Taylor and Francis Group, 2010.
2) Chris Mi, M.Abul Masrur and David Wenzhong Gao, 1st Edition, Hybrid Electric Vehicles, John Wiley & Sons, Ltd, 2011.

L	T	P	Cr.
4	0	0	4

B.Tech. (Sem.) **20MEH4-ENERGY STORAGE SYSTEMS**

Pre-requisites: Thermodynamics, Thermal Engineering.

Course Educational Objective:

To provide the insights on different types of energy storage systems, principles of energy storage and applications.

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

CO1: Understand the need and scope of energy storage systems. **(Understanding - L2)**

CO2: Comprehend the different types of energy storage systems. **(Understanding - L2)**

CO3: Describe the direct energy storage and conversion systems. **(Understanding - L2)**

CO4: Apply fundamental design principles for sizing of battery storage. **(Applying - L3)**

CO5: Understand the hybrid energy storage systems and future technologies. **(Understanding - L2)**

UNIT – I

INTRODUCTION: Necessity of energy storage, different types of energy storage, mechanical, chemical, electrical, electrochemical, biological, magnetic, electromagnetic, thermal, comparison of energy storage technologies.

UNIT - II

ENERGY STORAGE SYSTEMS: Thermal Energy storage, sensible and latent heat, phase change materials, Energy and Exergy analysis of thermal energy storage, Electrical Energy storage-super-capacitors, Magnetic Energy storage-Superconducting systems, Mechanical-Pumped hydro, flywheels and pressurized air energy storage, Chemical-Hydrogen production and storage.

UNIT - III

DIRECT ENERGY STORAGE SYSTEMS: Introduction, Characteristic features of energy storage system, Photovoltaic energy storage, Electrochemical Energy Storage- Battery, primary, secondary and flow batteries.

DIRECT ENERGY CONVERSION SYSTEMS: Principle of direct energy conversion using fuel cells, thermodynamics of fuel cells, Types of fuel cells, AFC, PEMFC, MCFC, and SOFC, Microbial fuel cell and its performance.

UNIT - IV

DESIGN AND APPLICATIONS OF ENERGY STORAGE: Renewable energy storage-Battery sizing and stand-alone applications, stationary (Power Grid application), Small scale application-Portable storage systems and medical devices.

UNIT - V

MOBILE STORAGE APPLICATIONS: Electric vehicles (EVs), types of EVs, batteries and fuel cells, future technologies, hybrid systems for energy storage.

TEXT BOOKS:

1. Energy Storage - Technologies and Applications by Ahmed Faheem Zobaa, In Tech.
2. Fundamentals of Energy Storage by J. Jensen and B. Sorenson, Wiley-Interscience, New York.
3. Handbook of battery materials by C. Daniel, J. O. Besenhard, Wiley VCH Verlag GmbH & Co. KgaA.
4. Electric & Hybrid Vehicles by G. Pistoia, Elsevier B. V.
5. Thermal energy storage: Systems and Applications by Dincer I. and Rosen M. A., Wiley pub.

REFERENCE BOOKS:

1. Energy Storage: Fundamentals, Materials and Applications, by Huggins R. A., Springer.
2. Fuel cell Fundamentals by R. O'Hayre, S. Cha, W. Colella and F. B. Prinz, Wiley Pub.
3. Chemical and Electrochemical Energy System by R. Narayan and B. Viswanathan, University Press.
4. Battery Systems Engineering by C. D. Rahn and C. Wang, Wiley Pub.
5. Electrochemical Energy Storage for Renewable sources and grid balancing by P. T. Moseley and J. Garche, Elsevier Science.
6. Compressed air energy storage by F. P. Miller, A. F. Vandome, M. B. John, VDM publishing.