Department of Mechanical Engineering

Honors

Title: Design Engineering

Sem	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
III	HON-01	*<tbd>*	Design for Manufacturing and Assembly	3	-	-	1	**3**	30	20	50	--	--
IV	HON-02	*<tbd>*	Stress Analysis	4	-	-	1	**4**	30	20	50	--	--
V	HON-03	*<tbd>*	MATLAB Programming and Simulink Modeling	3	-	2	1	**4**	30	20	50	50	50
VI	HON-04	*<tbd>*	Advanced Vibration and Acoustics	3	-	2	1	**4**	30	20	50	50	50
VII	HON-05	*<tbd>*	Optimization Techniques in Design	3	-	-	1	**3**	30	20	50	--	--
			Total	**16**	**-**	**04**	**05**	**18**					

Title: Thermal Engineering

Sem	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
III	HON-01	*<tbd>*	Renewable energy systems	3	-	-	1	**3**	30	20	50	--	--
IV	HON-02	*<tbd>*	MATLAB Programming and Simulink Modeling	3	-	2	1	**4**	30	20	50	50	50
V	HON-03	*<tbd>*	Computational Fluid Dynamics	3	-	2	1	**4**	30	20	50	50	50
VI	HON-04	*<tbd>*	Introduction to modeling and simulation of hydrogen technology	4	-	-	1	**4**	30	20	50	--	--
VII	HON-05	*<tbd>*	Electronic cooling systems	3	-	-	1	**3**	30	20	50	--	--
			Total	**16**	**-**	**04**	**05**	**18**					

Interdisciplinary Minor

Title: Smart Mobility and Green Energy Systems

Sem	Course Type	Course Code	Course Name	L	T	P	S	Cr	Evaluation Scheme				
									Theory			Laboratory	
									MSE	TA	ESE	ISE	ESE
III	IDP-01	*<tbd>*	Energy Storage System for EV	3	-	-	1	3	30	20	50	--	--
IV	IDP -02	*<tbd>*	IOT for Electric Vehicle	4	-	-	1	**4**	30	20	50	--	--
V	IDP -03	*<tbd>*	Introduction to hydrogen technology	4	-	-	1	**4**	30	20	50	--	--
VI	IDP -04	*<tbd>*	CAD/CAM	3	-	2	1	**4**	30	20	50	50	50
VII	IDP -05	*<tbd>*	Optimization Techniques in Design	3	-	-	1	**3**	30	20	50	--	--
			Total	**17**	**-**	**02**	**05**	**18**					

Detailed Syllabi- Honors in Design Engineering

Design for Manufacturing and Assembly						
Course Code	*<tbd>*		**Examination Scheme**			
Teaching Scheme	3-0-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: --	ESE: --	--

Course Outcomes: Students will be able to:

1. Comprehend the product development cycle
2. Identify the manufacturing issues that must be considered in the mechanical engineering design process
3. Apply the principles of assembly to minimize the assembly time
4. Make out the effect of manufacturing process and assembly operations on the cost of product
5. Apply tools and methods to facilitate development of manufacturable mechanical designs.

Introduction: **[4 Hrs]**

Need Identification and Problem Definition; Concept Generation and Evaluation; Embodiment Design

Selection of Materials and Shapes **[6 Hrs]**

Properties of Engineering Materials; Selection of Materials; Selection of Shapes; Co-selection of Materials and Shapes.

Selection of Manufacturing Process **[6 Hrs]**

Review of Manufacturing Processes; ; Design for Bulk Deformation Processes: Design for Sheet Metal Forming Processes; Design for Machining; Design for Powder Metallurgy; Design for Polymer Processing; Co-selection of Materials and Processes

Assembly Processes: **[6 Hrs]**

Review of Assembly Processes; Design for Welding; Design for Brazing and Soldering; Design for Adhesive Bonding; Design for Joining of Polymers; Design for Heat Treatment;

Design for Reliability and Quality **[6 Hrs]**

Failure Mode and Effect Analysis; Design for Quality; Design for Reliability; Approach to Robust Design

Modern methods of Manufacturing **[6 Hrs]**

Rapid Prototyping & Reverse Engineering, their applications,

Textbooks:

[1] G Boothroyd, P Dewhurst and W Knight, Product design for manufacture and assembly, John Wiley, NY: Marcel Dekkar, 1994.

Reference Books:

[1] M F Ashby and K Johnson, Materials and Design - the art and science of material selection in product design, Butterworth-Heinemann, 2003.

[2] G Dieter, Engineering Design - a materials and processing approach, McGraw Hill, NY, 2000.

[3] G Boothroyd, P Dewhurst and W Knight, Product design for manufacture and assembly, John Wiley, NY: Marcel Dekkar, 1994.

<table>
<tr><th colspan="7">Stress Analysis</th></tr>
<tr><td>Course Code</td><td colspan="2"></td><td colspan="4">Examination Scheme</td></tr>
<tr><td>Teaching Scheme</td><td>4-0-0-0</td><td></td><td>Theory</td><td>TA: 20</td><td>MSE: 30</td><td>ESE: 50</td></tr>
<tr><td>Credits</td><td>4</td><td></td><td>Laboratory</td><td>CIE: --</td><td>ESE: --</td><td>--</td></tr>
<tr><td colspan="7">Course Outcomes: Students will be able to:</td></tr>
<tr><td colspan="7">1. Students will understand the tensorial approach of continuum mechanics and will be able to comprehend modern research material.
2. Student will learn basic field equations such as equilibrium equations, compatibility and constitutive relationship.
3. Students will be able to apply basic field equations to torsion, bending and two dimensional problems, energy methods and plastic hinges.
4. Students will be proficient in framing correct boundary conditions while using FEM software packages.</td></tr>
<tr><td colspan="6">Continuum & Tensors, Stress tensor:</td><td>[8 Hrs]</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="6">Displacement and strains, compatibility relations</td><td>[8 Hrs]</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="6">Conservation Laws, Constitutive relations and Linear Elasticity, Dislocations and plastic deformation in metals</td><td>[8 Hrs]</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="6">Two dimensional problems, Torsion, Bending, Energy methods,</td><td>[8 Hrs]</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="6">Plasticity in structures:</td><td>[8 Hrs]</td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="6">Thick cylinders and Disks, Contact stresses</td><td></td></tr>
<tr><td colspan="7"></td></tr>
<tr><td colspan="7">Textbooks:</td></tr>
<tr><td>[1]</td><td colspan="6">Sadd, Martin H., Elasticity: Theory, applications and Numerics, Academic Press 2005 (Text Book)</td></tr>
<tr><td colspan="7">Reference Books:</td></tr>
<tr><td>[1]</td><td colspan="6">Srinath, L S, Advanced Mechanics of Solids, Tata McGraw Hill Education Pvt. Limited, New Delhi, 2009</td></tr>
<tr><td>[2]</td><td colspan="6">Budynas, R. G. Advance strength and Applied Stress Analysis, Second Edition, WCB/ McGraw Hill 1999</td></tr>
<tr><td>[3]</td><td colspan="6">Dally, J. W. and W.F. Riley, Experimental Stress Analysis, McGraw Hill International, Third Edition, 1991</td></tr>
</table>

MATLAB Programming and Simulink Modeling						
Course Code			**Examination Scheme**			
Teaching Scheme	3-0-2-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	4		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Apply MATLAB programming fundamentals for engineering computations.
2. Develop MATLAB programs using arrays, functions, loops and conditional statements.
3. Apply numerical methods and data visualization techniques using MATLAB.
4. Develop and simulate engineering system models using Simulink.
5. Analyze mechanical and thermal engineering systems using MATLAB and Simulink tools.

Introduction to MATLAB Environment:	**[6 Hrs]**
Introduction to MATLAB, MATLAB interface, command window, workspace, editor, variables and constants, operators, input/output commands, vectors and matrices, matrix operations, built-in mathematical functions, scripts and live scripts.	
MATLAB Programming Fundamentals:	**[8 Hrs]**
Conditional statements, loops, nested loops, user-defined functions, anonymous functions, file handling, debugging techniques, symbolic computations and applications in engineering problems.	
Numerical Methods and Data Visualization:	**[8 Hrs]**
Numerical solution of algebraic equations, interpolation, curve fitting, numerical differentiation and integration, solution of ordinary differential equations, 2D and 3D plotting, contour plots, animation and graphical visualization.	
Introduction to Simulink Modeling:	**[10 Hrs]**
Simulink environment, block libraries, signal flow diagrams, subsystem creation, modeling and simulation of first-order and second-order systems, simulation parameters, scopes and visualization tools.	
Engineering Applications using MATLAB and Simulink	**[10 Hrs]**
Modeling and simulation of mechanical systems, thermal systems and control systems, vibration analysis, optimization techniques, data acquisition and engineering case studies using MATLAB and Simulink.	

Textbooks:

[1]	Rudra Pratap, “Getting Started with MATLAB”, Oxford University Press.
[2]	Amos Gilat, “MATLAB: An Introduction with Applications”, Wiley India
[3]	Stephen Chapman, “MATLAB Programming for Engineers”, Cengage Learning.
[4]	Rao V. Dukkipati, “MATLAB and Simulink for Engineers”, New Age International.

Reference Books:

[1]	Palm III, “Introduction to MATLAB for Engineers”, McGraw Hill.
[2]	Karris, “Introduction to Simulink with Engineering Applications”, Orchard Publications.
[3]	Attaway, “MATLAB: A Practical Introduction to Programming and Problem Solving”, Butterworth-Heinemann.

List of Experiments:

[1]	Introduction to MATLAB environment and basic operations
[2]	Matrix manipulation and mathematical computations.
[3]	MATLAB programming using loops and conditional statements.
[4]	Development of user-defined functions and scripts.
[5]	Numerical solution of algebraic equations using MATLAB.
[6]	Curve fitting and interpolation techniques.
[7]	Numerical differentiation and integration.
[8]	Solution of ordinary differential equations using MATLAB.

[9]	2D and 3D plotting techniques.
[10]	Introduction to Simulink and basic block operations
[11]	Modeling and simulation of first-order systems using Simulink.
[12]	Modeling and simulation of second-order mechanical systems.
[13]	Simulation of thermal systems using Simulink.
[14]	Mini project based on MATLAB and Simulink applications in mechanical engineering.

<table>
<tr><th colspan="7">Advanced Vibration and Acoustics</th></tr>
<tr><td>Course Code</td><td colspan="2"></td><td colspan="4">Examination Scheme</td></tr>
<tr><td>Teaching Scheme</td><td>3-0-2-0</td><td></td><td>Theory</td><td>TA: 20</td><td>MSE: 30</td><td>ESE: 50</td></tr>
<tr><td>Credits</td><td>4</td><td></td><td>Laboratory</td><td>CIE: ---</td><td>ESE: ---</td><td>--</td></tr>
<tr><td colspan="7">Course Outcomes: Students will be able to:</td></tr>
<tr><td colspan="7">1. Model and analyze SDOF vibratory systems with or without damping subjected to periodic and aperiodic force/base excitations, and mathematically represent different excitation functions such as impulse, step, ramp, and half-sinusoidal inputs.
2. Predict the response of damped and undamped SDOF systems subjected to arbitrary excitations using convolution integral and evaluate Shock Response Spectrum (SRS) for engineering applications..
3. Formulate equations of motion for MDOF systems and determine eigenvalues, natural frequencies, and mode shapes using orthogonality properties and modal analysis techniques for harmonic and arbitrary excitations.
4. Apply analytical and computational techniques such as Rayleigh–Ritz method, Holzer method, Dunkerley's method, and Stodola's method to determine natural frequencies and mode shapes of discrete and continuous systems.
5. Explain fundamental concepts of acoustics, acoustic wave propagation, psychoacoustics, and noise control, and perform vibration and acoustic signal measurement and FFT-based analysis using accelerometers, microphones, and signal analyzers.</td></tr>
<tr><td colspan="6">Transient Vibrations</td><td>[4 Hrs]</td></tr>
<tr><td colspan="7">Transient Vibrations, Response of a single degree of freedom system to step and any arbitrary excitation, convolution (Duhamel's) integral, impulse response function.</td></tr>
<tr><td colspan="6">Vibration of Discrete Systems</td><td>[8 Hrs]</td></tr>
<tr><td colspan="7">Free, damped and forced vibrations of two degree of freedom systems, use of Lagrange's equations to derive the equations of motion, normal modes and their properties, multi degree of freedom systems, Eigen values and Eigen vectors, mode summation method</td></tr>
<tr><td colspan="6">Vibration of Continuous systems</td><td>[6 Hrs]</td></tr>
<tr><td colspan="7">Continuous Systems, Vibrations of strings, bars, shafts and beams, discretised models of continuous systems and their solutions using Rayleigh – Ritz method, Mode summation method,</td></tr>
<tr><td colspan="6">Vibration control and Numerical methods</td><td>[8 Hrs]</td></tr>
<tr><td colspan="7">Vibration Control, Methods of vibration control, principle of superposition, Numerical and computer methods in vibrations: Rayleigh, Rayleigh-Ritz and Dunkerley's methods, matrix iteration method for Eigen-value calculations, Stodola method, Holzer's method,</td></tr>
<tr><td colspan="6">Introduction to Acoustics:</td><td>[5 Hrs]</td></tr>
<tr><td colspan="7">Plane and Spherical acoustic waves, Transmission Phenomena, transmission from one fluid medium to another, normal incidence, reflection at the surface of a solid, standing wave patterns, transmission through three media, Resonators and filters, Absorption of sound waves in fluids : Phase log between pressure and condensation, viscous absorption of plane waves, heat conduction as a source of acoustic attenuation,</td></tr>
<tr><td colspan="6">Speech, Hearing, and Noise</td><td>[6 Hrs]</td></tr>
<tr><td colspan="7">Speech, Hearing and Noise, The voice mechanism, acoustic power output of a speech, anatomy of the ear, mechanism of hearing, thresholds of the ear, loudness, pitch and timbre, beats, aural harmonics and combination tones, masking by pure tones, masking by noise</td></tr>
<tr><td colspan="7">Text Books:</td></tr>
<tr><td>[1]</td><td colspan="6">Thomson W.T., "Theory of Vibrations with applications", George Allen and Unwh Ltd. London, 1981.</td></tr>
</table>

[2]	S.S. Rao, Addison, “Mechanical Vibrations”, Wesley Publishing Co., 1990
[3]	Leonard Meirovitch, “Fundamentals of vibrations”, McGraw Hill International Edition
[4]	S. Timoshenko, “Vibration problems in Engineering”, Wiley, 1974.
[5]	Lawrence E. Kinsler and Austin R.Frey, “Fundamentals of acoustics”, Wiley Eastern Ltd., 1987.
[6]	Michael Rettinger, “Acoustic Design and Noise Control”, Vol. I & II. , Chemical Publishing Co., New York, 1977

Optimization Techniques in Design

Course Code			**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: ---	ESE: ---	--

Course Outcomes: Students will be able to:

1. Formulate an optimization problem.
2. Apply algorithms for unconstrained optimization.
3. Apply algorithms for constrained optimization.
4. Find the optimum solution using nontraditional optimization techniques

Introduction:	**[6 Hrs]**
Introduction to optimization, classification of optimization problems, classical optimization techniques,	
Linear Programming:	**[7 Hrs]**
Linear programming, simplex method and Duality in linear programming, sensitivity or post-optimality analysis, Karmarkar's methods,	
Nonlinear Programming:	**[6 Hrs]**
Non-Linear Programming: - One-dimensional minimization, unconstrained and constrained minimization, direct and indirect methods	
Geometric Programming:	**[7 Hrs]**
Geometric programming, Optimum design of mechanical elements like beams, columns, gears, shafts, etc.	
Multibody Optimization:	**[8 Hrs]**
Introduction to multi-objective optimization, genetic Algorithms, Operators, applications in multi-objective optimization	

Reference Books:

[1]	Kalyanmoy Deb, "Optimization for Engineering Design", Prentice Hall of India, New Delhi, 2005.
[2]	R.C. Johnson, "Optimum Design of Mechanical Elements", Willey, New York, 1980
[3]	Kalyanmoy Deb, "Evolutionary multi-objective optimization, Willey, New York
[4]	S. S. Stricker, "Optimising performance of energy systems" Battelle Press, New York, 1985
[5]	J. S. Arora, "Introduction to Optimum Design", McGraw Hill, New York, 1989
[6]	L.C.W. Dixon, "Non-Linear Optimisation - Theory and Algorithms", Birkhauser, Boston, 1980.

Detailed Syllabi- Honors in Thermal Engineering

Renewable Energy Systems						
Course Code			**Examination Scheme**			
Teaching Scheme	3-1-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE:	ESE:	--

Course Outcomes: Students will be able to:

1. Analyze the performance of solar energy conversion systems.
2. Performance analysis of various wind energy conversion systems.
3. Compare various bio-energy conversion methods
4. Explore various ocean energy resources such as tidal, wave and ocean thermal energy and geothermal energy systems.

Introduction to renewable energy	**[6 Hrs]**
Energy demand growth and supply: Historical Perspectives, Fossil fuels, Consumption and Reserve; Environmental Impacts of Burning of Fossil fuels. Sustainable development and role of renewable energy sources	
Solar Energy:	**[6 Hrs]**
The Sun as an energy source and its movement in the sky. Solar energy received on the earth; Primary and Secondary Solar energy and Utilization of Solar Energy. Solar concentrators and tracking; Dish and Parabolic trough concentrating generating systems, Central tower solar thermal power plants; Solar ponds. Photovoltaic cells.	
Wind Energy:	**[6 Hrs]**
Types of turbines, Coefficient of Power, Betz limit, Wind electric generators, Power curve; wind characteristics and site selection; Potential of wind electricity generation in India and its current growth rate.	
Biomass Energy:	**[6 Hrs]**
Sources and Characteristics; Wet biogas plants; Biomass gasifiers: Classification and Operating characteristics; Updraft and Downdraft gasifiers; Gasifier based electricity generating systems.	
Ocean Energy:	**[6 Hrs]**
Tidal power plants: single basin and double basis plants, Variation in generation level; Ocean Thermal Electricity Conversion (OTEC)	
Power generation from Waves:	**[6 Hrs]**
Shoreline and Floating wave systems. Geothermal Energy: Conversion technologies- Steam and Binary systems; Geothermal power plants.	

Textbooks:

[1]	G.D Rai, “Non-Conventional Energy Source”, Khanna Publishers,2008.
[2]	D.O. Hall and R.P. Overend, “Biomass Regenerable Energy”, John Wiley and Sons, NewYork, 1987. 11
[3]	Freris L.L, “Wind Energy Conversion Systems”, Prentice Hall1990
[4]	John W. Twidell and Anthony D.Weir, “Renewable Energy Resource”, Taylor & Francis, 2006.
[5]	Sukhatme, S.P. and Nayak, J.K., “Solar Energy - Principles of Thermal Collection and Storage”, Tata McGraw Hill, New Delhi, 2008.
[6]	John A. Duffie, William A and Beckman “Solar Engineering of Thermal Processes” Fourth Edition, Wiley,2013
[4]	C.P. Kothandaraman and S. Subramanyam, “Heat and Mass Transfer Data Book,” New Age International, Mumbai

MATLAB Programming and Simulink Modeling						
Course Code			**Examination Scheme**			
Teaching Scheme	3-0-2-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	4		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Apply MATLAB programming fundamentals for engineering computations.
2. Develop MATLAB programs using arrays, functions, loops and conditional statements.
3. Apply numerical methods and data visualization techniques using MATLAB.
4. Develop and simulate engineering system models using Simulink.
5. Analyze mechanical and thermal engineering systems using MATLAB and Simulink tools.

Introduction to MATLAB Environment:	**[6 Hrs]**
Introduction to MATLAB, MATLAB interface, command window, workspace, editor, variables and constants, operators, input/output commands, vectors and matrices, matrix operations, built-in mathematical functions, scripts and live scripts.	
MATLAB Programming Fundamentals:	**[8 Hrs]**
Conditional statements, loops, nested loops, user-defined functions, anonymous functions, file handling, debugging techniques, symbolic computations and applications in engineering problems.	
Numerical Methods and Data Visualization:	**[8 Hrs]**
Numerical solution of algebraic equations, interpolation, curve fitting, numerical differentiation and integration, solution of ordinary differential equations, 2D and 3D plotting, contour plots, animation and graphical visualization.	
Introduction to Simulink Modeling:	**[10 Hrs]**
Simulink environment, block libraries, signal flow diagrams, subsystem creation, modeling and simulation of first-order and second-order systems, simulation parameters, scopes and visualization tools.	
Engineering Applications using MATLAB and Simulink	**[10 Hrs]**
Modeling and simulation of mechanical systems, thermal systems and control systems, vibration analysis, optimization techniques, data acquisition and engineering case studies using MATLAB and Simulink.	

Textbooks:

[1]	Rudra Pratap, "Getting Started with MATLAB", Oxford University Press.
[2]	Amos Gilat, "MATLAB: An Introduction with Applications", Wiley India
[3]	Stephen Chapman, "MATLAB Programming for Engineers", Cengage Learning.
[4]	Rao V. Dukkipati, "MATLAB and Simulink for Engineers", New Age International.

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[2]	Karris, "Introduction to Simulink with Engineering Applications", Orchard Publications.
[3]	Attaway, "MATLAB: A Practical Introduction to Programming and Problem Solving", Butterworth-Heinemann.

List of Experiments:

[1]	Introduction to MATLAB environment and basic operations
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[6]	Curve fitting and interpolation techniques.

[7]	Numerical differentiation and integration.
[8]	Solution of ordinary differential equations using MATLAB.
[9]	2D and 3D plotting techniques.
[10]	Introduction to Simulink and basic block operations
[11]	Modeling and simulation of first-order systems using Simulink.
[12]	Modeling and simulation of second-order mechanical systems.
[13]	Simulation of thermal systems using Simulink.
[14]	Mini project based on MATLAB and Simulink applications in mechanical engineering.

Computational Fluid Dynamics						
Course Code			**Examination Scheme**			
Teaching Scheme	3-0-2-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	4		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Understand the discretization procedure of the governing equations
2. Prepare the problem definition of a given fluid flow heat transfer problem
3. Decide the governing equations, boundary conditions, initial conditions etc for the given problem
4. To carry out the simulations and obtain the results in terms of dependent variables
5. Analyze the CFD results through post processing to obtain engineering parameters

Introduction to CFD: **[6 Hrs]**

Computational approach to Fluid Dynamics and its comparison with experimental and analytical methods, Basics of PDE: Elliptic, Parabolic and Hyperbolic Equations.

Governing Equations: **[7 Hrs]**

Review of Navier-Stokes Equation and simplified forms, Solution Methodology: FDM and FVM with special emphasis on FVM, Stability, Convergence and Accuracy..

Finite Volume Method: **[6 Hrs]**

Domain discretizations, types of mesh and quality of mesh, SIMPLE, pressure velocity coupling, Checkerboard pressure field and staggered grid approach.

Geometry Modelling and Grid Generation: **[7 Hrs]**

Practical aspects of computational modeling of flow domains, Grid Generation, Types of mesh and selection criteria, Mesh quality, Key parameters and their importance.

Methodology of CFDHT: **[8 Hrs]**

Objectives and importance of CFDHT, CFDHT for Diffusion Equation, Convection Equation and Convection-Diffusion Equation

Solution of N-S Equations for Incompressible Flows: **[8 Hrs]**

Semi-Explicit and Semi-Implicit Algorithms for Staggered Grid System and Non Staggered Grid System of N-S Equations for Incompressible Flows

Reference Books:

[1]	John A. Anderson, Jr.,Computational Fluid Dynamics, The Basic with applications by John A. Anderson, Jr., McGraw Hill International editions, Mechanical Engineering series.
[2]	Dr. Suhas Patankar, Numerical Heat Transfer and Fluid Flow, Crc Press
[3]	H.K. Versteeg, W.Malalasekera, Introduction to Computational Fluid Dynamics, An: The Finite Volume Method, PHI; 2nd edition.
[4]	Ferziger and Peric, Computational Methods for Fluid Dynamics, Springer Publication
[5]	Chuen-Yen Chow, An Introduction to Computational Fluid Mechanics, Seminole Pub Co.
[6]	Muralidhar K (Author), Sundararajan , Computational Fluid Flow & Heat Transfer, Narosa Publishing House

Introduction to modeling and simulation of hydrogen technology						
Course Code			**Examination Scheme**			
Teaching Scheme	4-0-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	4		**Laboratory**	CIE: --	ESE: --	--

Course Outcomes: Students will be able to:

1. Explain key modeling and simulation philosophies and tools for hydrogen energy systems, with distinctions between 0D–3D and steady-state vs. dynamic models.
2. Apply fundamental principles of electrochemistry and thermodynamics to model hydrogen production and consumption processes, including the calculation of relevant thermodynamic properties.
3. Develop and analyze simulation models for hydrogen production technologies such as water electrolysis, with an ability to implement steady-state and dynamic simulations.
4. Construct equivalent models for hydrogen application technologies (including fuel cells, engines, and turbines) and evaluate their performance using simulation tools.
5. Perform techno-economic assessments of hydrogen systems using levelized cost analysis and critically appraise the economic viability of advanced hydrogen technologies.

Overview of modelling and simulation approaches: **[6 Hrs]**

Modelling and simulation philosophy, type of models – 0D-3D, steady-state vs dynamic, physics-based models, data-driven models, hybrid models, availability of 0D/1D simulation environments – MATLAB/Simulink, Python, GT-POWER.

Basic principles in Hydrogen production and consumption processes: **[7 Hrs]**

Overview of electrochemistry - chemical equilibrium, reaction rates, basic thermodynamics – enthalpy, entropy, Gibbs free energy, calculation of reversible voltages at STP, basic power electronics – rectifiers, inverters, DC/DC and AC/AC converters.

Modeling Hydrogen production technologies – Water Electrolysis: **[6 Hrs]**

Overview of various Hydrogen generation technologies – biomass gasification, thermolysis (solar, nuclear, with and without catalysts), photocatalysis, methane decomposition, water electrolysis. Overview of water electrolysis techniques for Green Hydrogen production (Alkaline, PEM and solid oxide). PEM electrolyser cell example - Deep dive into electrical, chemical and mechanical equivalent steady state models in 0D, steady-state vs dynamic simulation.

Modelling Hydrogen application technologies – Fuel cells: **[7 Hrs]**

Challenges with Hydrogen storage and transportation design, Overview of various Hydrogen application technologies – Hydrogen internal combustion engine, Hydrogen gas turbine, fuel cells. Overview of power generation techniques using Fuel cells (Alkaline, PEM and solid oxide). PEM fuel cell example - Deep dive into electrical, chemical and mechanical equivalent steady-state models in 0D, steady state vs dynamic simulation.

Modeling for techno-economic analysis of advanced energy devices: **[8 Hrs]**

Key performance indicators to assess technology, levelized cost of X analysis e.g. LCOH, making various investment decisions, future trends in modelling and simulations, future trends in Hydrogen technologies

Reference Books:

[1]	Modeling, Design, and Simulation of Systems with Uncertainties, Authors: Andreas Rauh, Ekaterina Auer, 1st Edition, 2011, Springer-Verlag Berlin Heidelberg ISBN: 978-3642159558,
[2]	Hydrogen and Fuel Cells: Emerging Technologies and Applications, Authors: Bent Sørensen, Giuseppe Spazzafumo, 3rd Edition, 2018, Academic Press (Elsevier) ISBN: 978-0-08-100708-2,
[3]	Hydrogen Fuel: Production, Transport, and Storage, Editor: Ram B. Gupta, 1st Edition, 2008, CRC Press (Taylor & Francis), ISBN: 978-1-4200-4575-8
[4]	Computational Fluid Flow & Heat Transfer, Muralidhar K, Sundararajan, Narosa Publishing House.

[5]	Fuel Cell Fundamentals, Authors: Ryan O'Hayre, Suk-Won Cha, Whitney Colella, Fritz B. Prinz, 3rd Edition, 2016, Wiley, ISBN: 978-1-119-11380-5, .
[6]	Electrochemical Methods: Fundamentals and Applications, Authors: Allen J. Bard, Larry R. Faulkner, Henry S. White, 3rd Edition, 2022, Wiley, ISBN: 978-1-119-33406-4
[7]	The Hydrogen Economy: Opportunities and Challenges, Editors: Michael Ball, Martin Wietschel, 1st Edition, 2010, Cambridge University Press, ISBN: 978-0-521-88216-3
[8]	Renewable Hydrogen Technologies: Production, Purification, Storage, Applications and Safety, Editors: Luis M. Gandía, Gurutze Arzamendi, Pedro M. Diéguez, 1st Edition, 2013, Elsevier, ISBN: 978-0-444-56352-1,

<table>
<tr><th colspan="7">Electronic Cooling Systems</th></tr>
<tr><td>Course Code</td><td colspan="2"></td><td colspan="4">Examination Scheme</td></tr>
<tr><td>Teaching Scheme</td><td>3-0-0-0</td><td></td><td>Theory</td><td>TA: 20</td><td>MSE: 30</td><td>ESE: 50</td></tr>
<tr><td>Credits</td><td>3</td><td></td><td>Laboratory</td><td>CIE: --</td><td>ESE: --</td><td>--</td></tr>
<tr><td colspan="7">Course Outcomes: Students will be able to:</td></tr>
<tr><td colspan="7">1. Understand the heat transfer mechanisms of electronic cooling systems and assess their capability and applicability
2. Describe different cooling techniques and its applications in various domains
3. Analyse new cooling methods in the present scenario and use of commercial tools</td></tr>
<tr><td colspan="6">Introduction to ECS:</td><td>[6 Hrs]</td></tr>
<tr><td colspan="7">Objectives of thermal control, heat sources, heat transmission, steady and unsteady heat transfer. Electronic equipment for airplanes, missiles, satellites, spacecraft, ships, submarines, personal computers, microcomputers and microprocessors.</td></tr>
<tr><td colspan="6">Cooling techniques:</td><td>[6 Hrs]</td></tr>
<tr><td colspan="7">i) Air cooling-natural cooling ii) Air cooling-forced convection iii) Liquid cooling. Thermal contact conductance, fundamentals of heat transfer across an interface, real contact area, applications to microelectronics, and enhancement of contact conductance. Extended surface arrays for air-cooled systems, parameterizations, the fin input admittance, and the limitations of the fin efficiency</td></tr>
<tr><td colspan="6">Introduction to impinging jet theory:</td><td>[6 Hrs]</td></tr>
<tr><td colspan="7">Introduction to impinging jet theory, description of the principal flow regimes, single nozzle and multi-nozzle test rig, Taxonomy of liquid jet impingement conditions. Unconfined: free surface and submerged jets, semi confined, submerged jets. Heat transfer for unconfined free-surface and submerged jets i) circular ii) planar jets. Multiple impinging jets. Synthetic jets design and measurement approaches, enhancing heat transfer with synthetic jets (free and forced convection).</td></tr>
<tr><td colspan="6">Heat pipe:</td><td>[6 Hrs]</td></tr>
<tr><td colspan="7">Introduction to heat pipe, working principle, thermal performance, design, thermal resistance considerations, types of heat pipes, cylindrical, flat, micro and oscillating heat pipes.</td></tr>
<tr><td colspan="7">Textbooks:</td></tr>
<tr><td>[1]</td><td colspan="6">Kakac Sadik, Yuncu Hafit, Hijikata, K. “Cooling of Electronic systems”, Springer Science Business Media, Dordrecht, 1994.</td></tr>
<tr><td>[2]</td><td colspan="6">Dave S. Steinberg “Cooling Techniques for Electronic Equipment”, John Wiley and sons Inc, Canada, 1991.</td></tr>
<tr><td>[3]</td><td colspan="6">S M Sohel Murshed “Electronics Cooling”, ExLi4EvA, 2016</td></tr>
<tr><td>[4]</td><td colspan="6">Madhusudan Iyengar, Karl J L Geisler, Bahgat Sammakia “Cooling of Microelectronic and Nanoelectronic Equipment: Advances and Emerging Research”, WSPC ltd, Singapore, 2015</td></tr>
<tr><td>[5]</td><td colspan="6">Bahman Zohuri “Heat pipe Design and Technology”, Taylor and Francis ltd, U.S., 2011</td></tr>
</table>

Detailed Syllabi- Interdisciplinary Minot in Mechanical Engineering

Energy Storage System for EV						
Course Code	*<tbd>*		**Examination Scheme**			
Teaching Scheme	3-0-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: --	ESE: --	--

Course Outcomes: Students will be able to:

1. Explain the fundamentals of energy storage systems for EV applications.
2. Analyze characteristics and performance of battery technologies..
3. Evaluate battery charging and management systems.
4. Analyze thermal management and safety aspects of EV batteries.
5. Assess emerging energy storage technologies for electric vehicles.

Introduction to Electric Vehicles and Energy Storage Systems **[5 Hrs]**

EV architecture, energy demand, need for energy storage, classification of storage systems, performance parameters.

Battery Technologies **[7 Hrs]**

Lead-acid, NiMH, Li-ion, solid-state batteries, battery chemistry, construction, working principles and applications.

Battery Characteristics and Testing **[6 Hrs]**

Capacity, energy density, power density, efficiency, SOC, SOH, cycle life, testing methods.

Battery Management Systems: **[6 Hrs]**

Definition of fluid, fluid properties such as viscosity, vapor pressure, compressibility, surface tension, capillarity, Mach number etc., pressure at a point in the static mass of fluid, variation of pressure, Pascal's law, pressure measurement by simple and differential manometers using manometric expression

Charging Infrastructure and Emerging Technologies **[6 Hrs]**

Fast charging, wireless charging, supercapacitors, hydrogen fuel cells, future trends

Textbooks:

[1] Iqbal Husain, "Electric and Hybrid Vehicles", CRC Press.

[2] Mehrdad Ehsani, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles", CRC Press.

[3] James Larminie and John Lowry, "Electric Vehicle Technology Explained", Wiley.

Reference Books:

[1] Gregory Plett, "Battery Management Systems", Artech House.

[2] Linden and Reddy, "Handbook of Batteries", McGraw Hill.

IOT for Electric Vehicle						
Course Code			**Examination Scheme**			
Teaching Scheme	4-0-0-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	4		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

5. Explain IoT architecture for EV systems..
6. Analyze sensor networks and communication protocols..
7. Develop EV monitoring and diagnostic systems.
8. Evaluate cloud-based EV applications.
9. Assess cybersecurity challenges in connected vehicles

Introduction to IoT and Electric Vehicles:	**[8 Hrs]**
Fundamentals of IoT, architecture of IoT systems, smart mobility, connected vehicles, embedded systems, overview of electric vehicles and EV subsystems, role of IoT in EV ecosystem.	
Sensors and Embedded Systems for EVs:	**[8 Hrs]**
Sensors used in EVs—temperature, current, voltage, pressure, position and speed sensors; signal conditioning, microcontrollers, embedded systems, actuators, data acquisition systems.	
Communication Protocols and Networking:	**[8 Hrs]**
CAN protocol, LIN, FlexRay, Bluetooth, ZigBee, Wi-Fi, MQTT, V2V and V2I communication systems, networking architecture in EVs and intelligent transportation systems.	
Cloud Computing and Data Analytics:	**[8 Hrs]**
Cloud platforms for EV monitoring, telematics systems, real-time monitoring, predictive maintenance, data logging, data analytics, machine learning basics for EV diagnostics and fleet management.	
Cybersecurity and Smart Mobility Applications:	**[8 Hrs]**
Cybersecurity challenges in connected vehicles, encryption and authentication, intelligent transportation systems, autonomous EV concepts, smart charging infrastructure and future trends in connected mobility.	

Textbooks:

[1]	Raj Kamal, “Internet of Things”, McGraw Hill.
[2]	Arshdeep Bahga and Vijay Madisetti, “Internet of Things”, Universities Press
[3]	Claus Kuhnel, “Getting Started with ESP32”, Packt.

Reference Books:

[1]	Olivier Hersent, “The Internet of Things”, Wiley.
[2]	Dieter Uckelmann, “Architecting the Internet of Things”, Springer.

Fundamentals of Green Hydrogen Technology						
Course Code			**Examination Scheme**			
Teaching Scheme	3-0-2-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	4		**Laboratory**	CIE: 50	ESE: 50	--

Course Outcomes: Students will be able to:

1. Explain the concept of the hydrogen economy and classify various hydrogen production pathways, with a focus on green hydrogen.
2. Analyze and compare different hydrogen production technologies, particularly electrolysis methods, and evaluate their efficiency and suitability for renewable energy integration.
3. Design and evaluate hydrogen storage and transportation systems considering technical, safety, and economic aspects.
4. Assess hydrogen utilization technologies including fuel cells and internal combustion systems, and explore their integration in industrial and transportation sectors.
5. Investigate emerging trends, policies, and case studies related to the global and national green hydrogen ecosystem, and propose solutions to current challenges.

Introduction to Hydrogen Economy and Green Hydrogen: **[6 Hrs]**

Overview of hydrogen as an energy carrier, Hydrogen economy: concepts, evolution, and need, Classification of hydrogen: grey, blue, green, turquoise, Role of green hydrogen in decarbonization, Current global and Indian scenario: policies, initiatives, and projects, Challenges and opportunities in green hydrogen deployment.

Hydrogen Production Technologies: **[7 Hrs]**

Alkaline Electrolyzers, Proton Exchange Membrane (PEM) Electrolyzers, Solid Oxide Electrolyser (SOE), Solar and wind energy integration for green hydrogen, Water purification and resource management for electrolysis, Biomass gasification and thermochemical routes, Techno-economic analysis and efficiency comparisons.

Hydrogen Storage and Transportation: **[6 Hrs]**

Physical storage: Compressed gas, Liquid hydrogen,

Material-based storage: Metal hydrides, Chemical carriers (ammonia, LOHCs), Storage system design considerations, Transportation methods: Pipelines, Cryogenic tankers, Hydrogen blending in NG pipelines, Safety standards, codes, and regulations.

Hydrogen Utilization and Applications: **[7 Hrs]**

Fuel cells: PEMFC, SOFC, applications and integration, Hydrogen in internal combustion engines (H2-ICE), Industrial applications: Steel, Fertilizer, Refineries.

Mobility and transportation: Fuel cell electric vehicles (FCEVs), hybrid systems,

Power-to-X technologies: Synthetic fuels, Ammonia, Methanol

Emerging Trends, Challenges, and Future Prospects: **[8 Hrs]**

Techno-economic analysis of hydrogen value chain, Hydrogen hubs, microgrids, and sector coupling, Carbon footprint and life-cycle assessment (LCA), Policy framework, incentives, and public-private partnerships, Case studies: National Hydrogen Mission (India), EU Hydrogen Strategy, HyDeploy, etc., Research opportunities and startup ecosystem

Textbooks:

[1]	Bent Sørensen, "Hydrogen and Fuel Cells: Emerging Technologies and Applications"
[2]	Antonio Scipioni, Alessandra Manzardo, Javier G. Pérez, “Hydrogen Economy: Supply Chain, Life Cycle Analysis and Energy Transition for Sustainability”. Academic Press

Reference Books:

[1]	Ryan O'Hayre, Suk-Won Cha, Whitney Colella, Fritz B. Prinz, "Fuel Cell Fundamentals", Wiley
[2]	Scott E. Grasm, "Hydrogen Energy and Vehicle Systems", CRC Press

Computer Aided Design & Manufacturing						
Course Code			**Examination Scheme**			
Teaching Scheme	3-0-2-0		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	4		**Laboratory**	CIE: ---	ESE: ---	--

Course Outcomes: Students will be able to:

1. Understand the fundamentals of Geometric modelling.
2. Develop and manipulate the curves using algebraic, parametric equations.
3. Develop and manipulate the surfaces using parametric equations.
4. Develop and manipulate the solid models using different modelling approaches.
5. Apply various 2-D and 3-D geometric transformations.
6. Examine CNC program for production of components.

Introduction: **[4 Hrs]**

Definitions, Historical developments. Geometric Modelling, Nameable Un-nameable shapes, Affine and convex combination. Introduction to Equations - Implicit, explicit, parametric. Coordinate systems, Concepts of Torsion and Curvature, Osculating Plane, Binormal Vector. Concepts of Continuity.

Design of Curves: **[8 Hrs]**

Cubic Hermite curves - Algebraic and geometric forms, Blending functions, Subdivision, Reparameterization, Truncating, Space curve, four point form, straight line and Composite Hermite curves (Cn & Gn continuity).

Spline curve, Bezier curves - Control polygons and Bernstein basis, De Casteljau algorithm, First and second derivatives at the ends, Continuity aspects.

B-Spline Curves - periodic, open and non-uniform knot vectors and corresponding curves, Rational B-Splines, NURBS.

Design of surfaces: **[6 Hrs]**

Hermite Surface - Algebraic and geometric form, tangent and twist vectors, blending functions, plane surface, cylindrical surface, ruled surface, surface of revolution. Bezier surface - Control net representation, Continuity aspects.

Introduction to Solid Modelling: **[8 Hrs]**

Topology, Generalized concept of boundary, set theory, Boolean operators (Union, Difference and Intersection).

Set memberships classification, Euler and modified form of equations. Solid model construction: Boolean models, Instances and parameterised shapes, sweep, Boundary Representation (B-Rep), Constructive Solid Geometry (CSG), Generative design

Geometric verses coordinate transformations: **[5 Hrs]**

2D geometric transformations, Homogeneous coordinate Composite transformations, 3D transformations, Inverse transformations, geometric mapping, Examples of transformation applications in mechanical engineering

Introduction to NC/CNC/DNC machines **[6 Hrs]**

Classification of NC systems, Axis nomenclature, Interpolation, features of CNC controllers, Types of CNC machines, Construction features of CNC machines, Manual Part Programming, NC word format, Details of G and M codes, Canned cycles, subroutines and Do loops, Tool radius and length compensations. Exercises on CNC turning center and machining center programming

List of Experiments

1. Formation of varying degree curves and studying their nature.
2. Study of Known shapes of curves and modelling them by Algebraic Forms
3. Study of Known shapes of curves and modelling them by Parametric Forms
4. Time Study of various parametric forms and algebraic of circle.
5. Formation of Hermite curves by –
    a) Varying Magnitude of a single tangent vector in a specified range.
    b) Varying Magnitude of a both tangent vectors in a specified range.

c) Varying Direction Cosines which impact direction of tangent vectors. 6. Study of Bezier Curve by – a. Reversal of control points defined b. Formation of close Bezier Curve with desired continuity C0, C1 **c.** Repeating Certain control points – Multiplicity study 7. Coding of B-Spline Curves a. Studying impact by Varying the control points b. Studying impact by Varying Degree of Curve 8. Coding for formation of Surfaces a. Ruled Surfaces / Tabulated Surface b. Surface of Revolution (Sphere, Cylindrical, Arbitrary Curve rotated about and axis) c. Bezier Surface 9. Construct a Boolean Tree Structure for a given 3d object with all the instances, scaling, rotation performed on the primitives utilized for the formation of object. 10. Assignment to check for Affine transformation properties of curves. a. Translation of curves / Known Figure b. Rotation of curves / Known Figure c. Scaling of Curves / Known Figure 11. Generative Design of Knuckle Joint, Bracket or any other component Under Realistic Load Conditions (Fusion 360 or other licensed software oncampus) 12. Assignment on CNC Coding for few specific workpieces.

Text Books:	
[1]	Michael E. Mortenson, Geometric Modeling, John Wiley & Sons; 2nd edition
[2]	Shigley J.E. and Mischke C.R."Mechanical Engineering Design" McGraw Hill Publ. Co.Ltd.
[3]	Ibrahim Zeid, R Sivasubramanian, CAD CAM Theory And Practice, Ibrahim Zeid, McGraw Hill Education; 2nd edition
[4]	Martti Mantyla, Introduction to Solid Modelling, Computer Science Press.
Reference Books:	
[1]	Gerald Farin, Curves and Surfaces for CAGD, Morgan Kaufmann Publishers In; 5th edition.
[2]	Les Piegl (Author), Wayne Tiller, The NURBS Book, Springer-Verlag.

Optimization Techniques in Design						
Course Code			**Examination Scheme**			
Teaching Scheme	3-0-0-1		**Theory**	TA: 20	MSE: 30	ESE: 50
Credits	3		**Laboratory**	CIE: ---	ESE: ---	--

Course Outcomes: Students will be able to:

1. Formulate an optimization problem.
2. Apply algorithms for unconstrained optimization.
3. Apply algorithms for constrained optimization.
4. Find the optimum solution using nontraditional optimization techniques.

Introduction:	**[6 Hrs]**
Introduction to optimization, classification of optimisation problems, classical optimisation techniques,	
Linear Programming:	**[7 Hrs]**
Linear programming, simplex method and Duality in linear programming, sensitivity or post-optimality analysis, Karmarkar's methods,	
Nonlinear Programming:	**[6 Hrs]**
Non-Linear Programming: - One dimensional minimization, unconstrained and constrained minimization, direct and indirect methods	
Geometric Programming:	**[7 Hrs]**
Geometric programming, Optimum design of mechanical elements like beams, columns, gears, shafts, etc.	
Multibody Optimization:	**[8 Hrs]**
Introduction to multi-objective optimization, genetic Algorithms, Operators, applications in multi-objective optimization	

Reference Books:

[1]	Kalyanmoy Deb, "Optimization for Engineering Design", Prentice Hall of India, New Delhi, 2005.
[2]	R.C. Johnson, "Optimum Design of Mechanical Elements", Willey, New York, 1980
[3]	Kalyanmoy Deb, "Evolutionary multi-objective optimization, Willey, New York
[4]	S. S. Stricker, "Optimising performance of energy systems" Battelle Press, New York, 1985
[5]	J. S. Arora, "Introduction to Optimum Design", McGraw Hill, New York, 1989
[6]	L.C.W. Dixon, "Non-Linear Optimisation - Theory and Algorithms", Birkhauser, Boston, 1980.