ACADEMIC CURRICULA

POST GRADUATE DEGREE PROGRAMMES

Master of Technology

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 25

Syllabi for School of Mechanical Engineering Programmes

Professional Core and Elective Courses

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

ACADEMIC CURRICULA

School of Mechanical Engineering

Professional Core Course

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21MAC501T	Course Name	COMPUTATIONAL METHODS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	1	0	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mathematics*	**Data Book / Codes / Standards**	*Statistical Tables*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn the concept of one dimensional wave equations and diffusion equation*
CLR-2:	*construct Fourier series for periodic functions and transform technique to solve elliptic equation*
CLR-3:	*understand the concepts of Euler's equations*
CLR-4:	*identify numerical technique to solve algebraic transcendental equations, ODE and PDE*
CLR-5:	*infer the concepts of probability, correlation and regression*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*explain analytical solution of partial differential equation*	*3*	*3*	
CO-2:	*justify the solution of elliptic type PDE and periodic functions*	*3*	*3*	
CO-3:	*evaluate the solution of functional and vibrational problems*	*3*	*3*	
CO-4:	*adapt numerical solutions for algebraic, transcendental, ODE and PDE*	*3*	*3*	
CO-5:	*solve Statistical problems related to day to day life*	*3*	*3*	

Module-1 - Transform Techniques	***12 Hour***
Laplace transform - Fourier transform - One-dimensional wave equation using Laplace transform methods - Displacements in long string - Longitudinal vibration of an elastic bar - One -dimensional diffusion equation using Fourier transform methods – One-dimensional diffusion equation using Fourier sine transform methods – One-dimensional diffusion equation using Fourier cosine transform methods. .	
Module-2 - Fourier Series and Elliptic Equation	***12 Hour***
Fourier series representation of periodic functions - Fourier transform methods for Laplace equation.	
Module-3 - Calculus of Variations	***12 Hour***
Euler's Equations - Functional involving x, y, y' - Functional on higher order derivatives - Functional dependent on functions of independent variables - Rayleigh-Ritz method.	
Module-4 – Numerical Methods	***12 Hour***
Solution of algebraic and transcendental equations-Iteration method-Newton's method- solution to ODE- Runge Kutta method of 4th order- Milne's predictor corrector method. Solution to PDE- Solution to Laplace equation-Leibman's method- Solution to Poisson equation- Solution to Parabolic type PDE- Bender Schmidt method-Crank Nicholson method.	
Module-5 - Statistical Techniques	***12 Hour***
Random Variables –Discrete and continuous random variables-Mean, median, variance, Standard deviation, moments, skewness, kurtosis, correlation, regression, coherence, multiple and partial correlation.	

Learning Resources	1. Sankara Rao, K., "Introduction to Partial Differential Equations", PHI, New Delhi, 3rd edition 2011. 2. B .V. Ramana, "Higher Engineering Mathematics", McGraw Hill Publication, 2017. 3. Elsgolts, L., "Differential Equations and Calculus of Variations", Mir Publishers, Moscow, 2013.	4. S. S. Sastry, Introductory Methods of Numerical Analysis, 5thEdition, PH1, 2012 5. S.C. Gupta, V.K. Kapoor, Fundamentals of Mathematical Statistics, Sultan Chand & Sons, 11th Edition, 2015. 6. S. Ross, A First Course in Probability, 8th Edition., Pearson Education India, 2010.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	25%	-	25%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Madhan Shanmugasundaram, Infosys Technologies, madshan@gmail.com	1. Prof. Y.V.S.S. Sanyasiraju, IIT Madras, sryedida@iitm.ac.in	1. Dr. V. Subburayan, SRMIST
	2. Prof. K.C. Sivakumar, IIT Madras, kcskumar@iitm.ac.in	2. Dr. P.Sambath. SRM IST

ACADEMIC CURRICULA

Solar Energy

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21MEC531J	Course Name	SOLAR RADIATION AND ENERGY CONVERSION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	Data Book / Codes / Standards	*(i) Solar Radiation and Energy Conversion Data Book, (ii) Heat and Mass transfer Data Book*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*know the solar energy potential and familiarize with solar radiation concepts*
CLR-2:	*familiarize with different components of solar radiation and measurements*
CLR-3:	*familiarize with the solar radiation geometry and estimation of the intensity of solar radiation*
CLR-4:	*familiarize with solar - thermal energy conversion*
CLR-5:	*familiarize with direct solar electric conversion*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand the solar energy potential and solar radiation concepts*	2	3	-
CO-2:	*understand the terrestrial solar radiation and measurement of its various components*	3	3	-
CO-3:	*understand solar radiation geometry and estimate the availability of solar radiation at a location*	3	3	-
CO-4:	*understand the solar thermal energy conversion techniques and approach*	3	3	-
CO-5:	*understand the direct solar-to-electrical energy conversion*	3	3	-

Module-1 – Energy Resources and Solar Spectrum ***15 Hour***

Energy, economy and social development – Classification of energy sources- Energy chain – Environmental aspects of energy – World energy status – Energy scenario in India – Electromagnetic spectrum – Solar spectrum – Basic laws of radiation – Black body radiation – Radiative properties – Tutorials on laws of radiation – Sun as a source of energy - Structure of the Sun – Solar Constant – Planetary energy balance – Earth's temperature – Greenhouse effect.

Practical 1 – Survey of the present status of energy resources in the world

Practical 2 - Survey of the present status of Indian energy resources

Practical 3 – Demonstration of greenhouse effect

Module-2 – Solar Radiation and Measurements ***15 Hour***

Extraterrestrial and Terrestrial Radiations – Spectral power distribution of solar radiation – Depletion of solar radiation – Air Mass – Measurement of Solar Radiation – Pyranometer – Pyrheliometer – Sunshine recorder – Solar Radiation Data – Latitude and Longitude – Standard Longitude – Standard time - Solar Time

Practical 1 – Measurement of global radiation by the pyranometer

Practical 1 – Measurement of diffuse radiation by pyranometer with shading ring

Practical 3 – Estimation of solar time for a location

Module-3 - Solar Radiation Geometry and Calculations ***15 Hour***

Solar radiation geometry – Angle of latitude, Declination, Hour angle, Inclination angle, Zenith angle, Solar Azimuth angle, Slope or tilt angle, Surface azimuth angle, Angle of incidence – Solar day length – Extraterrestrial solar radiation on a horizontal surface – Terrestrial solar radiation on a horizontal surface – Solar radiation on an inclined plane surface. *Practical 1 – Estimation of solar day length on any day for a location;* *Practical 2 – Estimation of solar radiation intensity (global and diffuse) on a horizontal surface of any location on any day and comparison with measured data; Practical 3 – Estimation of solar radiation intensity (global and diffuse) on an inclined surface of any location on any day and comparison with measured data.*	
Module-4 - Solar Thermal Energy Conversion	***15 Hour***
Types of Solar Collectors – Solar water heater - Solar passive space heating and cooling – Solar Industrial heating systems - Solar refrigeration and air conditioning systems – Solar driven vapour absorption cooling system - Solar Cookers, box type and parabolic dish type – Solar greenhouse – Solar Dryer – Solar Desalination – Heat engine cycle – Components of a solar thermal power plant - Solar pond electric power plant – Distributed collector solar thermal electric power plant – Central tower receiver power plant – Solar chimney plant. *Practical 1 - Performance study of a solar box cooker* *Practical 2 – Performance calculation of a solar steam generation plant* *Practical 3 – Estimation of heat losses of a solar receiver*	
Module-5 – Solar Electrical Energy Conversion	***15 Hour***
Solar PV Technology: Advantages and limitations - Basic solar cell structure – Protection of solar cells - Solar cell, PV Module, PV Panel, PV Array— Solar PV Module ratings and cost – Rated power and actual power from a module – Solar PV systems and their components – Battery ratings and cost – Inverter ratings and cost – Electric current conduction in semiconductors – PN junction – Photoconduction – I-V & P-V characteristics of solar cell – Maximum power point - Short circuit current - Open circuit voltage - Fill factor – Efficiency *Practical 1 – Determination of I-V characteristics of a solar module and power output* *Practical 2 - Determination of I-V characteristics of solar modules connected in series* *Practical 3 - Determination of I-V characteristics of solar modules connected in parallel*	

Learning Resources	*1. Duffie J.A., Beckman W.A. "Solar Engineering of Thermal Processes", 3rd ed., Wiley, 2006.Kern D.Q, "Process Heat Transfer", Tata McGraw Hill , 1997, Reprint 2008* *2. Kalogirou S., Solar Energy Engineering: Processes and Systems, Elsevier, 2009. Arthur. P Frass, "Heat Exchanger Design", John Wiley & Sons, 1988.* *3. Yogi Goswami D., Frank Kreith, Jan F. Kreider, Principles of Solar Engineering, Second Edition, Taylor & Francis, 2003.* *4. B.H.Khan, Non-Conventional Energy Resources, Third Edition, McGraw Hill Education (India) Private Limited, 2017.*	*5. De Vos, A., Thermodynamics of Solar Energy Conversion, Wiley-VCH, 2008.Lieke Wang, Bengt Sundén, Raj M. Manglik., Plate Heat Exchangers: Design, Applications and Performance, WIT Press, 2007.* *6. Foster R., Ghassemi M., Cota A., Solar Energy, CRC Press, 2010.Wolverine Heat Transfer Data book – III by Wolverine Tube Inc.,* *7. Garg H.P., Prakash J., Solar Energy Fundamentals and Applications, Tata McGraw-Hill, 2005* *8. Sukhatme, S.P., Solar Energy, Tata McGraw Hill,4th Edition,2017.*

Learning Assessment							
	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2 (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	-	-	20%	-
Level 2	Understand	20%	-	-	20%	20%	-
Level 3	Apply	30%	-	-	20%	30%	-
Level 4	Analyze	30%	-	-	30%	30%	-
Level 5	Evaluate	-	-	-	30%	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri Email: r_kalimuthu@vssc.gov.in	1. Dr. G.Kumaresan, CEG, Anna University, Chennai -25	1. Dr. M. Cheralathan, SRMIST
1. Dr.A.Velayutham, DRDO, Avadi Email: velayudham.a@cvrde.drdo.in	2. Dr. Raju Abraham, Scientist - F, National Institute of Ocean Technology, Chennai-601 302. E-mail: abraham@niot.res.in	2. Dr. V. Thirunavukkarasu,, SRMIST

Course Code	21MEC532J	Course Name	FLUID MECHANICS AND HEAT TRANSFER	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	Data Book / Codes / Standards	*Heat and Mass Transfer Data Book, Steam Tables*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*familiarize with the basic laws of fluid flow and the boundary layer concept*
CLR-2:	*familiarize with the incompressible flow through the ducts*
CLR-3:	*know the concepts of conduction and radiation heat transfer*
CLR-4:	*familiarize with the concepts of convective heat transfer*
CLR-5:	*familiarize with the phase change heat transfer and design of heat exchanger*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*analyze the governing equations for fluid flow problems*	2	2	-
CO-2:	*analyze incompressible flow through ducts*	3	3	-
CO-3:	*solve the conduction and radiation heat transfer problems*	3	3	-
CO-4:	*solve the convective heat transfer problems*	3	3	-
CO-5:	*analyze phase change heat transfer and heat exchanger performance*	3	3	-

Module-1 - Fluid Flow and Boundary Layer Concept	***15 Hour***
Classification of fluids, Three-dimensional continuity equation, equations of momentum, Experiment on flow measuring devices – Venturi meter, Energy equation, Rotational and irrotational flows, circulation – vorticity – stream and potential functions, Experiment on flow measuring devices – orifice meter, Boundary Layer over a flat plate: Laminar flow, displacement and momentum thickness, Experiment on flow measuring devices – Pitot tube	
Module-2 - Flow through Conduits	***15 Hour***
Laminar flow between parallel plates, flow through circular pipe, Verification of Bernoulli's theorem, Friction factor –smooth pipe, Turbulent flow in pipes, friction factor for rough pipes, Friction factor calculation - Moody diagram, Losses in flow through pipes, Evaluation of pressure drop in circular pipe: CFD simulation, Pipes in series and parallel, transmission of power through pipes, Tutorial in pipes series, parallel combination, Evaluation of major loss through pipes	
Module-3 - Conduction and Radiation Heat Transfer	***15 Hour***
Governing Equation for one-dimensional conduction -through plane wall, cylinder and sphere, Boundary conditions, critical thickness of insulation, Conduction with thermal energy generation, Heat transfer through composite wall, Extended surface Heat Transfer- types of fin conditions, Fin optimization, Fin effectiveness and Fin efficiency, Unsteady heat conduction -lumped capacitance method and its validity, Heat transfer through pin fin – Natural & Forced convection Radiation Heat Transfer- Fundamental concepts, Radiation exchange between surfaces black and grey surfaces, Gas radiation-radiation transfer in enclosures containing absorbing and emitting media, Stefan Boltzmann apparatus	
Module-4 - Convective Heat Transfer	***15 Hour***
Blasius solution for boundary layer equations for laminar flow over a flat plate, scale analysis, skin friction coefficient, Laminar boundary layer equations for heat transfer over a flat plate, Nusselt number, forced and natural convection, analogy between heat and momentum transfer: Reynolds analogy and Colburn analogy, Heat transfer in internal flows: circular pipe, turbulent flows, turbulence modelling-two equation models, Experiments: Forced convection heat transfer in horizontal tube, Free convection heat transfer in vertical tube, Practice in turbulence models	
Module-5 – Phase Change Heat Transfer and Heat Exchangers	***15 Hour***

Boiling – pool boiling regimes, Correlations, Flow boiling, Film and Dropwise condensation, Boiling heat transfer – critical heat flux, Conduction with Phase change -Integral method, Solidification -Numerical methods, Melting- Numerical methods, Practice in solidification of PCM in different geometries, Heat exchanger – LMTD and NTU approach, Design procedure – Sizing and rating, Compact heat exchangers-Plain and Tube heat exchangers, Experiment on the determination of the effectiveness of Tubular heat exchanger

Learning Resources	1. *Streeter, V.L., Wylie, E.B., and Bedford, K.W., Fluid Mechanics, WCB McGraw Hill, Boston, 2017* 2. *Bansal,R.K., Fluid Mechanics, Saurabh and Co., New Delhi, 2016.* 3. *Ozisik. M.N., Heat Transfer – A Basic Approach, McGraw-Hill Co., 1985.* 4. *Holman.J.P., Heat Transfer, Tata McGraw Hill, 2008*	5. *Ghoshdastidar.P.S., Heat Transfer, Oxford University Press, second edition,2012.* 6. *Cengel, Yunus A., John M. Cimbala, Robert H. Turner, and Mehmet Kanoglu. Fundamentals of thermal-fluid sciences. McGraw-Hill Higher Education, 2017* 7. *C.P.Kothandaraman, S.Subramanyan, Heat and Mass transfer Data book, New Age International Publishers,2018*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2 (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	-	-	20%	-
Level 2	Understand	20%	-	-	20%	20%	-
Level 3	Apply	30%	-	-	20%	30%	-
Level 4	Analyze	30%	-	-	30%	30%	-
Level 5	Evaluate	-	-	-	30%	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri,	1. Dr.R.Velraj, Professor, Anna University, Chennai	1. Dr. P. Sudhakar, SRMSIT
2. Dr.A.Velayutham, DRDO, Avadi,	2. Dr. Shaligram Tiwari, Professor, IITM, Chennai	2. Dr. D. Siva Krishna Reddy, SRMIST

Course Code	21MEC533J	Course Name	SOLAR THERMAL COLLECTORS AND APPLICATIONS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	**Data Book / Codes/Standards**	*Heat and Mass Transfer Data Book, Steam Tables*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1 :	*familiarize with solar thermal collectors*
CLR-2 :	*analyze the performances of solar flat plate collectors*
CLR-3 :	*familiarize with solar concentrating collectors*
CLR-4 :	*analyze the performances of solar-concentrated collectors*
CLR-5 :	*familiarize with the applications of solar collectors*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CO-1 :	*understand the solar thermal collectors*	*3*	-	-
CO-2 :	*assess the performances of solar flat plate collectors*	*3*	*2*	-
CO-3 :	*understand the solar concentrating collectors*	*3*	*2*	-
CO-4 :	*assess the performances of solar concentrators*	*3*	-	-
CO-5 :	*understand the applications of solar collectors*	*3*	*2*	-

Module-1 - Basics of Solar Collectors	***12 Hour***
Fundamentals of solar collectors, Classifications solar collector, Concentrating Collector, Non-concentrating Collector, Evacuated type collectors, Solar air heaters configuration, Construction details of solar collectors, Practice on fundamentals of Solar Fluidic Systems, Design and structures of collectors for heating of liquids.	
Module-2 - Performances of Flat Plate Solar Collectors	***12 Hour***
Optimal collector tilt and orientation, Thermal analysis, Energy balance on solar air heater performance, Modelling of solar air heaters, Useful energy gain, Energy losses and efficiency, Use of selective coatings to enhance the collector efficiency, Flat Plate collectors for low and medium-temperature applications, Experiment on Solar Flat Plate collectors -thermosyphon mode, Experiment on Solar Flat Plate collectors – Forced mode.	
Module-3 - Concentrating Solar Collectors	***12 Hour***
Concentrating collectors, Various types - Line and point focusing: Parabolic trough, A case study online-focusing collector, Parabolic dish collectors, Heliostat field with central receiver, Sun tracking mechanisms, A case study on point-focusing Collector, Fresnel lenses, Advances in line and point-focusing collectors, Case studies on Concentrated solar collectors, Hands-on - Parabolic dish concentrator.	
Module-4 - Performances of Solar Concentrators	***12 Hour***
Concentrating collector design and performance evaluation, Concentration ratio, Energy Balance, Practical on performance evaluation of parabolic trough collector - Useful energy gain, Energy losses, Collector efficiency. Practical on Performance evaluation of parabolic dish collector, Installation procedures of collectors, Testing of collectors, Operation and maintenance of solar collectors, A Case study on solar steam cooking plant.	
Module-5 – Applications of Solar Collectors	***12 Hour***
Application of non-concentrating collectors in low temperature solar thermal plants for space heating and cooling, Solar cooling using vapour absorption refrigeration and air-conditioning systems, Solar Drying, Case study on Solar dryers, Seawater desalination, Types and Stills, Use of concentrating collectors for process heat production, Real field Challenges, Case study on Space Heating System, Solar ponds, Performance study of solar pond, Solar greenhouse effects. Case studies on solar stills.	

Learning Resources	1. Artur V. Kilian, "Solar Collectors: Energy Conservation, Design and Applications", Nova Science Publishers Incorporated, 2009. 2. Soteris A. Kalogiru, "Solar Energy Engineering: Processes and systems", 1st edition, Academic press, 2009. 3. Sukhatme .K, Suhas P.Sukhatme., "Solar energy: Principles of thermal collection and storage", Tata McGraw Hill publishing Co. Ltd, 8th edition, 2008. 4. Duffie.J. A & Beckman. W.A, "Solar Engineering of Thermal Processes", 3rd edition, John Wiley & Sons, Inc., 2006.	5. Garg .H.P,Prakash .J, "Solar energy fundamentals and applications", Tata McGraw Hill publishing Co. Ltd, 2006. 6. Yogi D. Goswami, Frank Kreith, Jan F.Kreider., "Principle of solar engineering", 2nd edition, Taylor and Francis, 2nd edition, 2003. 7. Tiwari. G.N, "Solar energy: Fundamentals, Design, Modeling and Applications", CRC Press Inc., 2002.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2 (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	-	-	20%	-
Level 2	Understand	20%	-	-	20%	20%	-
Level 3	Apply	30%	-	-	20%	30%	-
Level 4	Analyze	30%	-	-	30%	30%	-
Level 5	Evaluate	-	-	-	30%	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Soumitra Mukhopadhyay, SMS India Pvt. Ltd, Kolkatta	1. Dr. Ravita Lamba, MNIT Jaipur	1. Dr. R. Senthil, SRM IST
2. Mr. M. Periyasamy, NLC India, Neyveli	2. Dr. G. Kumaresan, Anna University Chennai	2. Dr. V. Thirunavukarasu, SRM IST

Course Code	21MEC534J	Course Name	SOLAR PHOTOVOLTAIC SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	*Mechanical Engineering*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*familiarize with semiconductor physics related to solar cell operation*
CLR-2 :	*be familiar with design, operation and performance of solar PV modules*
CLR-3 :	*be familiar with various PV technologies and balance of components*
CLR-4 :	*familiarize with the standalone and grid tied solar power systems*
CLR-5 :	*be familiar with solar PV applications, economics and environmental impacts*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CLO-1 :	*explain the semiconductor physics related to solar cell operation*	2	-	3
CLO-2 :	*apply the design, operation and performance of solar PV modules*	2	-	3
CLO-3 :	*explain the various PV technologies and balance of components*	2	-	3
CLO-4 :	*design the standalone and grid tied solar power systems*	2	-	2
CLO-5 :	*illustrate the solar PV applications, economics and environmental impacts*	2	-	3

Module-1 - Physics of Solar Cells	***15 Hour***
Introduction and crystal structure, Energy bands and Energy gap, Carrier concentration- Intrinsic carrier concentration, donors and acceptors, Carrier concentration-Fermi level, Fermi-Dirac distribution, p-n Junction, Carrier transport phenomenon-Drift and Diffusion, Absorption, recombination and carrier lifetime, p-n Junction: forward and reverse, Solar cell, Dark characteristics and light characteristics. Case study: Introduction to Jawaharlal Nehru National Solar Mission, Visual comparison of single crystalline, polycrystalline and amorphous solar panels, Solar cells efficiency charts.	
Module-2 - Design of PV Modules	***15 Hour***
Cell design-Collection probability and junction depth, Doping of substrate, Back surface fields, Top layer limitations doping effects, saturation current density, Top contact design, Optical design- texturing and anti-reflective coating, Production process of single crystalline silicon cells, multi-crystalline silicon cells, I-V Characteristics of Solar Cell, MPP, Characteristic resistance, Efficiency limits- Short circuit current, Open circuit voltage, Effect of Temperature, Solar cells in series and parallel, shading-bypass diode, half cut solar cells, Influence of shunt and series resistance, Maximum power point tracking. Practice: Measurement of open circuit voltage and short circuit current of solar PV module, Determination of I-V and P-V characteristics of Solar PV module. Case study: Electroluminescence testing of Solar PV module.	
Module-3 - PV Technologies and Balance of Systems	***15 Hour***
Homojunctions and Heterojunction, Crystalline and thin film solar cells, Gallium Arsenide, CdTe, Micromorph solar cells, Concentrated Photovoltaics, Solar concentration and tracking requirements, Multi gap solar cells, Bifacial Solar cells, Effect of pitch, height of installation and albedo, Mounting of bifacial solar module, DC-DC converters and charge controllers, Batteries, cables and inverters, PV Module standards. Determination of I-V and P-V characteristics of a series combination of Solar PV modules, Determination of I-V and P-V characteristics of the parallel combination of Solar PV modules. Case study: IEC Solar PV standards.	
Module-4 - Design of Solar PV Power Systems	***15 Hour***
PV Power system design selection requirements, Standalone PV power system, Load calculation, inverter and battery sizing, Distributed power system, Net metering, Grid-tied and grid interactive systems, Solar farm, Soiling in solar PV modules, Degradation of solar panels and cells, PV panels installation structural load calculations, Floating PV power plants, Agrovoltaic systems, Building integrated PV system, Hybrid	

renewable power system, Practice: Determination of performance characteristics of PV module with variation in tilt angle, effect of shading on PV module power output, Case study: Floating, and agrovoltaic solar power plant.
Module-5 – Solar PV Applications ***15 Hour***
Design of Solar water pumping system, Solar Street light design, Solar lantern, Thermal imaging of solar PV module, Solar cars, Solar charging stations, Solar aircraft, Solar PV for satellites, solar PV-Thermal collectors, Design of Solar PV power systems, Environmental impacts of solar PV systems, Socio-economic impacts of Solar PV systems, Cost analysis of standalone and grid-tied PV power system. Practice: Solar Water pumping system. Case study: Payback period evaluation of standalone PV power system.

Learning Resources	1. *Sze, Simon M., and Kwok K. Ng. Physics of semiconductor devices. John wiley& sons, 2006.* 2. *Wenham, Stuart R., Martin A. Green, Muriel E. Watt, Richard Corkish, and Alistair Sproul. Applied photovoltaics. Routledge, 2013.* 3. *Green MA. Solar cells: operating principles, technology, and system applications. Englewood Cliffs, NJ, Prentice-Hall, Inc., 2009.* 4. *Solanki, Chetan Singh. Solar photovoltaics: fundamentals, technologies and applications. PHI Learning Pvt. Ltd., 2015.*	5. *Kopecek, Radovan, and JorisLibal, eds. Bifacial Photovoltaics: Technology, applications and economics. Institution of Engineering and Technology, 201* 6. *Mertens, Konrad. Photovoltaics: fundamentals, technology, and practice. John Wiley & Sons, 2018* 7. *Report: All-India survey of photovoltaic module reliability: 2018. Nat. Centre Photovolt. Res. Educ. (2018).* *https://www.pveducation.org/pvcdrom (Website)*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2 (15%)		Summative Final Examination (40% weightage)	
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	-	-	20%	-
Level 2	Understand	20%	-	-	20%	20%	-
Level 3	Apply	30%	-	-	20%	30%	-
Level 4	Analyze	30%	-	-	30%	30%	-
Level 5	Evaluate	-	-	-	30%	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Soumitra Mukhopadhyay, SMS India Pvt. Ltd, Kolkatta	1. Dr. Ravita Lamba, MNIT Jaipur	1. Dr. S. Manikandan, SRM IST
2. Mr. M. Periyasamy, NLC India, Neyveli	2. Dr. V. Sakthi Vadivel, VIT Vellore	2. Dr. Joji Johnson, SRM IST

ACADEMIC CURRICULA

Computer Aided Design & Solar Energy

Common Professional Elective Course

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21MEE505T	Course Name	MECHANICAL BEHAVIOR OF ENGINEERING MATERIALS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	The purpose of learning this course is to:
CLR-1:	*familiarize the structure and properties of materials*
CLR-2:	*familiarize tension and torsion loading*
CLR-3:	*understand about fatigue and creep behaviors*
CLR-4:	*familiarize fracture mechanics concepts and theory*
CLR-5:	*understand mechanical properties of non-metallic and composite materials*

Course Outcomes (CO):	At the end of this course, learners will be able to:	Programme Outcomes (PO)		
		1	2	3
CO-1:	*recognize and analyze the structure and properties*	*2*		
CO-2:	*acquire knowledge on tension and torsion load responses*	*1*	*2*	
CO-3:	*acquire knowledge on fatigue and creep*	*1*		
CO-4:	*acquire knowledge on fracture mechanics*	*2*		
CO-5:	*understand mechanical properties of non-metallic and composite materials*	*2*	*2*	

Module	Hours
Module-1 - Structure and Properties	***7 Hour***
Crystal Structures, planes and directions; Defects in crystals, Crystal anisotropy; Microstructure, Dislocation and Twining; Strengthening mechanisms.	
Module-2 - Tension and Torsion	***8 Hour***
Stress - Strain curve, Complex stress/strain states, Elasticity, Isotropic and Anisotropic; Elastic-Plastic Deformation, Yielding, Ductility; Residual Stresses; Strain hardening exponent; Strain rate sensitivity; Mechanical properties in torsion, Tensile test, Compression test; Types of torsion failures, Torsion test, Measuring shear stress, Hardness, micro-hardness and nano-indentation.	
Module-3 - Fatigue and Creep	***10 Hour***
Fatigue phenomena; Theories of fatigue failure; Evaluation of fatigue resistance; Parameters influencing fatigue; Cyclic stress strain behavior; Design against fatigue; Description of creep, Creep curve, Stress-rupture test, Creep mechanisms, Creep in two phase alloys; Materials aspects creep design; Creep fracture.	
Module-4 - Fracture Mechanics	***10 Hour***
Types of fracture; Griffith's Theory; Irwin - Orowan Theory - crack propagation Modes; Ductile fracture; Analysis of crack propagation; Stress intensity factor; Crack opening displacement; J integrals; Measuring elastic-plastic fracture mechanics parameters.	
Module-5 – Properties of Non-Metallic Materials and Composites	***10 Hour***
Rheological behavior: Viscoelasticity and hyperelasticity in polymers; Flow and deformation behavior of polymer, ceramics and glasses; Deformation behavior of metal sandwich plate and metal-matrix composite material; Failure in Polymers; Failure fiber reinforced composites; Failure in Ceramics, Toughening mechanisms.	

Learning Resources	*1. George E. Dieter, "Mechanical Metallurgy", McGraw Hill,1986.* *2. Thomas H. Courtney, "Mechanical Behaviour of Materials", McGraw Hill 2017*	*3.. Joachim Roesler, Harald Harders, Martin Baeker, Mechanical Behaviour of Engineering Materials, Springer, 2007* *4. Joseph Marin, "Mechanical Behaviour of Engineering Materials", Prentice-Hall of India Pvt. Ltd., 1966*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Sandip Ghosh Chowdhury, CSIR-NML Jamshedpur, sgc@nmlindia.org	1. Prof. Debdulal Das, IIEST Shibpur, debdulal_das@metal.iiests.ac.in	1. Dr. Shubhabrata Datta, SRMIST
2. Dr. Srinivas Gunti, Tata Motors, Pune, rsg770075@tatamotors.com	2. Prof. Pijush Ghosh, IIT Madras, pijush@iitm.ac.in	2. Dr. Kumaran D, SRMIST

Course Code	21MEE605J	Course Name	COMPUTATIONAL FLUID DYNAMICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*get familiarity with governing equations of fluid mechanics and their mathematical behavior*
CLR-2:	*understand the intricate details of discretization techniques and stability analysis of difference equations*
CLR-3:	*know various numerical methods to solve equations and solution technique for compressible flows*
CLR-4:	*grasp techniques for coupling continuity and momentum equations for incompressible flows, SIMPLE algorithm and its application to Couette flow*
CLR-5:	*be familiar with concepts of turbulence and its modelling*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*derive governing equations to a fluid system and classify governing equations mathematically*	*2*	*2*	-
CO-2:	*implement different discretization techniques to solve simple PDEs, and perform stability analysis*	*3*	*3*	-
CO-3:	*analyze the solution techniques for algebraic, ordinary differential and partial differential equations and applying to solve compressible flows*	*3*	*3*	-
CO-4:	*evaluate the solution techniques for elliptic equations and apply them to potential flows, incompressible flows and specifically to Couette flow*	*3*	*3*	-
CO-5:	*evaluate the concept of turbulence and Reynold's averaging and* examine the *turbulence modelling approaches*	*3*	*3*	-

Module-1 - Governing Equations	***12 Hour***
Equations Introduction, Various applications of computational fluid dynamics, Models of fluid flow, Continuity equation derivation in all forms, Momentum, Energy and Scalar transport equations derivation, Conservation and Non-conservation form of governing equations, Different types of boundary conditions –Dirichlet, Neumann, Cauchy and Robbins boundary conditions with examples, Classification and Mathematical behaviour of Partial differential equations – elliptic, parabolic and hyperbolic, well-posed problems. Practical- Introduction to commercial CFD software, Simulation of flow over a flat plate for laminar conditions	
Module-2-Discretization Techniques	***12Hour***
Discretization concept and principles, Finite difference approximations of partial derivatives – Forward, Backward and Central difference methods, Discretization of one-dimensional un-steady state heat conduction, Explicit and Implicit method, Discretization of one-dimensional wave equation, Tutorials on discretization of equations, Stability analysis of different equations, consistency and convergence, Discussion on CFL condition, Short discussion on shock capturing methods: Godunov, TVD, flux-limiter schemes. Practical: Coding on explicit and implicit schemes and simulation of flow over circular pipe for laminar conditions with commercial CFD software conditions.	
Module-3 - Solution Techniques and Numerical Methods for Compressible Flows	***12 Hour***
Direct methods for system of linear equations: Gauss elimination method and Tri-diagonal matrix algorithm (TDMA), Iterative methods: Gauss-Siedel, Jacobi and relaxation techniques, Solution techniques for ordinary differential equations: Euler, predictor-corrector, Runge-Kutta (4 stages) methods, Linear multi-step methods: Adams-Bashforth method, Short discussion on algebraic multi-grid method, Application of McCormack technique to compressible flows: case study- Supersonic flow through convergent-divergent nozzle: Governing equations, numerical method, boundary conditions, case set-up and results, Tutorials on McCormack method, Coding practice for Jacobi method. Practical: Coding on TDMA, and relaxation techniques, Supersonic flow simulation in a convergent-divergent nozzle with commercial CFD software	
Module-4 Solution Techniques for Elliptic and Parabolic Equations	***12 Hour***

Application of relaxation techniques to potential flow equation, Application of Alternating Direction Implicit (ADI) method to unsteady two-dimensional heat conduction, Techniques for incompressible Navier-Stokes equations: Concept of staggered grid., Pressure correction method, SIMPLE algorithm and boundary conditions, Solution of Couette flow using SIMPLE algorithm. Practical: Coding on ADI method, Grid convergence study on flat plate flow with Fluent	
Module-5 – Introduction to Turbulence Modelling	***12 Hour***
Concept of Turbulent boundary layer over a flat plate: Laminar sub, logarithmic and outer layers, Concept of turbulence, Reynolds averaging, Time-averaged equations for turbulent flow, Boussinesq approximation, Types of turbulence models: Prandtl mixing length, One-equation, Two-equation models, Comparison of different turbulent models, Energy cascade mechanism in turbulent flows, Advanced methods: Large Eddy Simulations, Direct Numerical Simulations, Detached Eddy Simulations. Practical: Turbulent simulation of flow in a circular pipe, flat plate, mixing layer with k-ε model with commercial CFD software.	

Learning Resources	1. *Anderson J.D., "Computational Fluid dynamics: The basics with Applications", McGraw Hill Education, July 2017.* 2. *Versteeg H.K., and Malalasekera W., "An introduction to computational fluid dynamics"The finite volume method", Pearson India Publisher, January 2010* 3. *3. Muralidhar.K, and Sundararajan.T, "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, Second Edition, 2008.*	4. *Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons, 2011.* 5. *5. R. Byron Bird, Warren E. Stewart, Edwin N. Lightfoot, "Transport Phenomena", 3rd Edition, John Wiley and Sons, 2013.* 6. *6. Piyush K. Kundu and Ira M. Cohen, "Fluid Mechanics", 4th Edition, Elsevier, 2010*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) Formative CLA-1 Average of unit test (50%)		Continuous Learning Assessment (CLA) Life-Long Learning CLA-2 (10%)		Summative Final Examination (40% weightage)	
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	15%	-	15%	-	15%	-
Level 2	*Understand*	15%	10%	15%	10%	15%	10%
Level 3	*Apply*	10%	10%	10%	10%	10%	10%
Level 4	*Analyze*	10%	10%	10%	10%	10%	10%
Level 5	*Evaluate*	10%	10%	10%	10%	10%	10%
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Anil Kumar, Fluidyn Consultancy Private Limited, Bengaluru.	*1. Dr. Arul Prakash, Professor, IIT Madras*	*1. Dr. D. Siva Krishna Reddy, SRMIST*
2. P. S. G. Kumar, Siemens Industry Software (India) Pvt Ltd, Bengaluru	*2. Dr. G. Kumaresan, Anna University Chennai*	*2. Dr. P.Sudhakar, SRMIST*

ACADEMIC CURRICULA

Solar Energy

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21MEE531T	Course Name	ENERGY CONSERVATION AND MANAGEMENT	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*familiarize with the energy conservation principles*
CLR-2:	*familiarize with the energy conservation in steam systems*
CLR-3:	*be familiar with the energy conservation in fluid machinery*
CLR-4:	*be familiar with the energy conservation in electrical systems*
CLR-5:	*familiarize with the energy management*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*recognize the importance of the energy conservation principles*	3	-	3
CO-2:	*analyze the energy conservation in thermal systems*	3	-	3
CO-3:	*analyze the energy conservation in fluid machinery*	3	-	3
CO-4:	*analyze the energy conservation in electrical systems*	3	-	3
CO-5:	*assess the investment decisions*	3	-	3

Module-1 - Energy Conservation Principles	***9 Hour***
Global Energy scenario, Indian energy scenario, sector-wise energy consumption, Principles of energy conservation, commercial and non-commercial energy, Primary energy resources, Energy needs of the growing economy, Long-term energy scenario, energy pricing, energy security, Commercial energy production, final energy consumption, Role of energy managers and auditors in industries, Energy audit Types, energy conservation Acts, a simple case study of energy auditing in energy-intensive industries.	
Module-2 - Energy Conservation in Thermal systems	***9 Hour***
Power plant components, Conservation measures in steam systems and losses in a boiler, Methodology of upgrading boiler performance, Blowdown control and excess air control, Thermo compressors, Pressure reducing stations, Condensate recovery and condensate pumping, Recovery of flash steam, air removal and venting, Cooling towers, Waste heat recovery systems, Case studies on energy conservative measures in boilers, condensers and evaporators.	
Module-3 - Energy Conservation in Fluid Machinery	***9 Hour***
Centrifugal pumps, Energy consumption and energy saving potentials, Design consideration and minimizing over design, Fans and blowers, specifications, Safety margin, choice of fans, Controls and design considerations, Air compressor and compressed air systems, Selection of compressed air storage systems, Energy conservation aspects in the design stage of fluid machinery. Case studies on Energy Conservation in Fluid Machinery.	
Module-4 - Energy Conservation in Electrical Systems	***9 Hour***
Demand control, power factor correction, Load scheduling and shifting, Electricity Transmission and Distribution, Energy Efficient Motors and Drives, Variable Speed Drives and Applications, Demand side management, Electricity Act, Energy Efficient Lighting Sources, fixtures, Daylighting, timers and energy efficient windows. Case studies on Energy conservation in Electrical systems	
Module-5 – Energy Management	***9 Hour***

Organizational background desired for energy management persuasion, Motivation, publicity role, Economics of various energy conservation schemes, Investment decisions, Energy management information systems (EMIS), Energy monitoring and targeting- elements, Energy consumption, production, the cumulative sum of differences (CUSUM), Energy policy and labelling, Energy conservation in Buildings, Energy Storage systems for Buildings and Industrial Process Heating applications.

Learning Resources	1. *Wayne C. Turner, Steve Doty, Energy Management Handbook Taylor and Francis, 9th edition, 2020.* 2. *Suresh Kumar Soni and Manoj Nair, "Energy Management and Audit", Satya Prakashan Publishers, 6th edition, 2016.* 3. *Suresh Kumar Soni and Manoj Nair, "Energy Conservation and Management", Satya Prakashan Publishers, 6th edition, 2016.*	4. *Smith. C.B., Energy "Management Principles", Pergamon Press, 2nd Edition, 2015.* 5. *Umesh Rathore, "Energy Management", S.K.Kataria & Sons, 2015.* 6. *Vilnis Vesma, Energy Management Principles and Practice 2nd edition British Standards Institution 2012.* 7. *Beggs.Clive, "Energy – Management, supply and conservation", Taylor and Francis, 2nd edition, 2009.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	10%	-	10%	-	10%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	10%	-	10%	-	10%	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. R. M. Raghunathan, Assistant Vice President, Tamil Nadu Petroproducts Limited, Manali, Chennai-600068. mlrmr@hotmail.com	1. Dr. Raju Abraham, NIOT, Chennai, abraham@niot.res.in	1. Dr. G. Balaji, SRMIST
2. Er. M. Sakthivel, Dy. Chief Engineer, NLC Limited, Neyveli – 607801, sakthivel.m@nlcindia.in	2. Dr. G. Arun Vijay, University College of Engineering, Kancheepuram, arunvijay.gs@gmail.com	2. Dr. G. Kasiraman, SRMIST

Course Code	21MEE532T	Course Name	ELECTRICAL DRIVES AND SMART GRID SYSTEM	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1 :	*familiarize with the fundamentals of electric drives*
CLR-2 :	*be familiar with control techniques in electrical drives*
CLR-3 :	*be familiar with smart grid infrastructure and technologies*
CLR-4 :	*familiarize with the power electronic systems for smart grid applications*
CLR-5 :	*be familiar with grid integration of electric vehicles*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CLO-1 :	*explain the fundamental concepts of electric drives*	2	-	3
CLO-2 :	*apply the control techniques for electric drives*	2	-	3
CLO-3 :	*explain the various technologies and smart grid infrastructure*	2	-	3
CLO-4 :	*design the power electronics for smart grid applications*	2	-	2
CLO-5 :	*illustrate the electric vehicle integration with grid*	2	-	3

Module-1 - Fundamentals of Electrical Drives	***9 Hour***
Introduction to electric drives and their applications, Power electronic switches, linear electronics vs power electronics, principles of electromechanical energy conversion, DC and AC motor characteristics and control techniques, and Power electronics for electric motor drives.	
Module-2 - Control Techniques in Electrical Drives	***9 Hour***
Review of classical and modern control theories, 1phase/3phase converter fed DC drives, Non-PWM and PWM VSI fed induction motor drives, principles of V/F control, Feedback control strategies for speed and torque regulation.	
Module-3 - Smart Grid Infrastructure and Technologies	***9 Hour***
Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart Grid- opportunities, challenges and benefits. Difference between conventional & Smart Grid, Integration of renewable energy sources into the grid, Power system stability and control in smart grids, Communication protocols and cybersecurity in smart grid systems, Grid modernization and smart metering technologies.	
Module-4 - Power Electronics for Smart Grid Applications	***9 Hour***
Introduction to power electronic converters in smart grid systems, Grid-connected converters for renewable energy integration, Energy storage systems and their interface with the grid, Design considerations and performance analysis of power electronics in smart grids. Substation Automation, Transmission systems: EMS, FACTS and HVDC, isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers.	
Module-5 – Grid Integration of Electric Vehicles	***9 Hour***
Electric vehicle (EV) technologies and market trends, Impact of EVs on the grid: challenges and opportunities, Vehicle-to-grid (V2G) integration and bidirectional power flow control, Charging infrastructure and smart charging algorithms, Case studies and simulation exercises on EV-grid integration scenarios.	

Learning Resources	1. *Mohan N, Raju S. Power Electronics, a First Course: Simulations and Laboratory Implementations. John Wiley & Sons; 2022 Dec 7.* 2. *Erickson RW, Maksimovic D. Fundamentals of power electronics. Springer Science & Business Media; 2007 May 8.* 3. *Kaźmierkowski MP, Krishnan R, Blaabjerg F, editors. Control in power electronics: selected problems. Academic press; 2002 Aug 20.*	4. *Momoh JA. Smart grid: fundamentals of design and analysis. John Wiley & Sons; 2012 Mar 7.* 5. *Garcia-Valle R, Lopes JA, editors. Electric vehicle integration into modern power networks. Springer Science & Business Media; 2012 Nov 29.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*10%*	-	*10%*	-	*10%*	
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	
Level 5	*Evaluate*	*10%*	-	*10%*	-	*10%*	
Level 6	*Create*		-		-		
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Soumitra Mukhopadhyay, SMS India Pvt. Ltd, Kolkatta	***1.** Dr. Ravita Lamba, MNIT Jaipur*	*1. Dr. S. Manikandan, SRM IST*
2. Mr. M. Periyasamy, NLC India, Neyveli	*2. Dr. V. Sakthi Vadivel, VIT Vellore*	*2. Dr. Joji Johnson, SRM IST*

Course Code	21MEE533T	Course Name	SOLAR REFRIGERATION AND AIR CONDITIONING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	Data Book / Codes / Standards	*Refrigeration Tables and Psychometric chart, Heat and Mass transfer Data Book*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*familiarize with solar photovoltaic based vapour compression cooling system*
CLR-2:	*familiarize with solar thermal energy based vapour absorption cooling system*
CLR-3:	*familiarize with solar assisted adsorption and desiccant cooling system*
CLR-4:	*familiarize with different types of solar active cooling systems*
CLR-5:	*familiarize with the different solar passive cooling system and learn economic evaluation of solar cooling systems.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*Design the PV system to operate vapour compression refrigerator*	*3*	*-*	*-*
CO-2:	*Understand the usage of solar thermal collectors for vapour absorption refrigeration system*	*3*	*2*	*-*
CO-3:	*Understand the concept of solar adsorption cooling and solar desiccant cooling system*	*3*	*2*	*-*
CO-4:	*Understand the different types of solar active cooling system and evaluate the performances*	*3*	*2*	*-*
CO-5:	*Understand different solar passive cooling techniques and perform economic evaluation of a solar cooling system.*	*3*	*2*	*-*

Module-1 - Solar Cooling and PV based Vapour Compression Cooling	***9 Hour***
Potential and scope of solar cooling, Need for solar cooling, Classification of solar cooling systems - Review of Psychrometric processes, Psychrometric chart - Cooling load calculations - Desirable properties of an ideal refrigerant - Vapour compression refrigeration system, T-s, H-s, P-v diagram - Photovoltaic powered refrigeration and air conditioning, Essential components of PV-assisted VCR system - Design of solar photovoltaic system for refrigeration and air conditioning application - Case study: PV system design for a VCR / air conditioning system, Performance evaluation of Solar PV assisted refrigerator - Performance evaluation of Solar PV assisted air conditioner.	
Module-2 - Solar Vapour Absorption System	***9 Hour***
Basics principle of absorption cooling, Properties of solvent, Solvent refrigerant combination properties - Vapour absorption refrigeration system - Performance evaluation of vapour absorption refrigeration cycle - Lithium Bromide-Water absorption System, Aqua-ammonia absorption system - Intermittent absorption refrigeration system - Solar assisted operation of vapour absorption refrigeration cycle, Performance evaluation of solar assisted vapour absorption system - Solar collectors for solar absorption cooling systems, Case study: Application of solar thermal energy to vapour absorption refrigeration system - Solar thermal energy storage system for absorption cooling system - Case study: Application of solar thermal energy storage system for operation of vapour absorption refrigeration during off sunshine Hour	
Module-3 - Solar Adsorption and Desiccant System	***9 Hour***
Adsorption refrigeration, Vapour adsorption cooling cycle, Thermodynamic processes of adsorption cycle - Closed cycle solar adsorption cooling system, Solar collectors for adsorption refrigeration systems - Selection of Adsorbent-Adsorbate materials in adsorption systems - Concept of Chemisorption systems and Metal hydride systems - Solar desiccant Cooling process - Air psychrometrics, Evaluation of Cooling capacity and COP - Desiccant materials: Selection and properties, Solid desiccant open cycle cooling systems, Solar-powered liquid desiccant systems - Solar-powered hybrid rotary desiccant wheel cooling systems - Case study of a hybrid VCR/VAR system.	

Module-4 - Other Types of Solar Active Cooling Systems	9 Hour
Rankine cycle-based solar cooling systems, Stirling cycle-based solar cooling systems Stirling refrigerator - Case study of integration of Rankine cycle/Stirling cycle with cooling system - Jet ejector compression solar cooling systems: Thermodynamic operation - Efficiency of ejector and COP of ejector cycle- Analysis - Performance evaluation of jet ejector compression solar cooling system - Fuel assisted solar cooling systems, Solar thermo acoustic cooling: Working principle, Components of solar thermo acoustic refrigerator - Solar thermoelectric refrigeration and air-conditioning - Design aspects of solar thermoelectric refrigerator - Performance evaluation of solar thermoelectric refrigerator, Advanced solar cooling concepts with case studies.	
Module-5 – Solar Passive Cooling and Economics	**9 Hour**
Passive cooling concepts, Evaporative and Radiative cooling - Case studies on integration of evaporative cooling and radiative cooling with building structure - Application of wind, water and earth for cooling, Shading, paints and cavity walls for cooling - Roof radiation trap system for building cooling - Earth air – tunnel system for cooling applications - Case study of earth air – tunnel heat exchanger system - Solar economics, Solar air conditioning cost evaluation - Payback period evaluation, net present worth and internal rate of return, Case study of payback period evaluation of typical solar desiccant cooling systems.	

Learning Resources	1. Kaushik ,S.C., Arora, A., Bilga, P. S., "Alternatives in Refrigeration and Air Conditioning", I.K. international Publishing House Pvt. Ltd., New Delhi, 2016 2. Kaushik, S.C , "Solar refrigeration and space conditioning", 1st Edition, Divyajyoti Prakashan, Jodhpur, 1989. 3. Tom, P. Hough, "Solar Energy: New Research", Nova Science Publishers, Inc, New York, 2006.	4. Wang R.Z and Ge T.S., "Advances in Solar Heating and Cooling", Woodhead Publishing series in Energy, No. 102, Elsevier Ltd., 2016. 5. Gerhard Stryi-Hipp, "Renewable Heating and Cooling", Woodhead Publishing series in Energy, No. 89, Elsevier Ltd., 2016. 6. Jan F. Kreider, "ASHRAE - Handbook of Fundamentals", American Society of Heating Refrigeration and Air Conditioning Engineers, CRC Press, New York, 2000

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	20%	-	20%	-	20%	-
Level 4	Analyze	20%	-	20%	-	20%	-
Level 5	Evaluate	20%	-	20%	-	20%	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Jayachandran Murugesan, Thermax Limited, India	1. Dr. R Velraj, CEG, Anna University, Chennai, velrajr@annauniv.edu	1. Dr. C. Selvam, SRMIST
2. Mr. Babu P, Thermax Limited, India	2. Dr.Raju Abraham, NIOT, Chennai, abraham@niot.res.in	

Course Code	21MEE534T	Course Name	SOLAR SYSTEMS FOR BUILDINGS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1 :	*familiarize with the energy resources and basics of the solar spectrum*
CLR-2 :	*know the concept of utilization of solar energy in buildings*
CLR-3 :	*familiarize solar energy as a source for heating and cooling of buildings*
CLR-4 :	*familiarize with solar PV systems for buildings*
CLR-5 :	*be familiar with the life cycle and economic analysis of materials used in solar systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CLO-1 :	*evaluate solar radiation geometry and perform related calculations*	*3*	*-*	*-*
CLO-2 :	*apply the concept of utilization of solar energy in buildings*	*3*	*2*	*-*
CLO-3 :	*design and relate solar thermal systems and their applications to buildings*	*3*	*2*	*-*
CLO-4 :	*design solar PV systems for building applications*	*2*	*-*	*-*
CLO-5 :	*review the basic economics of solar buildings*	*3*	*2*	*-*

Module-1 - Energy Resources and Solar Spectrum	***9 Hour***
Introduction to energy resources and solar spectrum, Solar radiation and measurement, Solar radiation geometry and calculations, Elements of buildings, traditional, modern, and alternative buildings, Concepts and elements of thermal comfort (Importance of ASHRAE standards), Materials and methods of construction, Thermal properties of building elements.	
Module-2 - Solar Heat Gain in Buildings	***9 Hour***
Introduction to solar heat gain in buildings, building orientations geometric shapes/factors, Building thermal resistance Computation of R and U Values for building elements and their comparison, Calculation of solar heat incident on various building surfaces, Diurnal and seasonal variation, Solar space conditioning.	
Module-3 - Solar Thermal System for Buildings	***9 Hour***
Introduction to solar thermal systems for buildings, Solar thermal systems for buildings, Intuitive and responsive building design, Case studies on solar thermal systems for buildings, Solar collectors and cookers, Thermal energy storage systems and their integration with buildings, Advantages and limitations - sizing, area, and performance calculations. Case studies on solar thermal systems with thermal energy storage.	
Module-4 - Solar PV Systems	***9 Hour***
Basics of solar PV systems, Solar PV systems for stand-alone and grid interconnected applications, Case studies on solar PV systems for stand-alone and grid interconnected applications, Integration of SPV components with buildings, Sizing, area and performance calculations, Case studies on sizing and performance of solar PV systems for buildings.	
Module-5 – Life Cycle and Economic Analysis	***9 Hour***
Basics of life cycle and economic analysis, Economic analysis for selection of materials, Economic analysis for alternative selection of materials, Case studies on economic analysis of solar systems for buildings, Life cycle analysis for thermal and electrical solar systems, Case studies on life cycle analysis of solar systems for buildings, Summary of concepts learnt from the course.	

Learning Resources	*1.Jan F. Kreider, The solar heating design process: active and passive systems, McGraw- Hill, 2007.* *2.David A. Bainbridge, Ken Haggard, Kenneth L. Haggard, Passive Solar Architecture: Heating, Cooling, Ventilation, Daylighting, and More Using Natural Flows, Chelsea Green Publishing, 2011.* *3.John Schaeffer, Doug Pratt, Douglas R. Pratt, Solar Living Sourcebook, 2007.* *4.A common-sense guide to alternative homebuilding by Clarke Snell, The Good House Book, April 1, 2004.* *5. Joseph F. Kennedy, Catherine Wanek, Michael G. Smith, The art of natural building: design, construction, resources, New Society Publishers, 2015.*	*6.Sukhatme and Nayak, Solar Energy: Principles Of Thermal Collection & Storage, Tata McGraw-Hill, 2008.* *7.Ibrahim Dincer and Marc A Rosan, Thermal Energy Storage: Systems & Applications, John Wiley, 2006.* *8.Duffie J.A. and Beckman W.A., 'Solar Engineering of Thermal Processes', Wiley, New York.1, 2013.* *9.Chetan Singh Solanki, Solar Photovoltaic Technology and Systems: A Manual for Technicians, Trainers and Engineers, PHI Publication, 2013.* *10.ANSI/ASHRAE Standard 55 – 2017, Thermal Environmental Conditions for Human Occupancy.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) Formative CLA-1 Average of unit test (50%)		Continuous Learning Assessment (CLA) Life-Long Learning CLA-2 (10%)		Summative Final Examination (40% weightage)	
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	20%	-	20%	-	20%	-
Level 4	Analyze	20%	-	20%	-	20%	-
Level 5	Evaluate	20%	-	20%	-	20%	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr.R.Kalimuthu, ISRO, Mahendragiri, r_kalimuthu@vssc.gov.in	1. Dr. G. Kumaresan, Anna University	1. Dr. P. Sundaram, SRMIST
2. Dr.A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	2. Dr. Joseph Daniel, VIT University Chennai	2. Dr. A. Sathishkumar, SRMIST

Course Code	21MEE537T	Course Name	ENERGY FORECASTING, MODELING AND PROJECT MANAGEMENT	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	Data Book / Codes/Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1 :	*analyze the energy availability and its changing pattern*
CLR-2 :	*analyze different forecasting models for energy management.*
CLR-3 :	*learn different optimization techniques for energy planning and management.*
CLR-4 :	*equip project proposals writing with proper cost estimation.*
CLR-5 :	*learn about the different energy policies.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CLO-1 :	*knowledge of energy patterns and availability.*	2	-	-
CLO-2 :	*ability to apply forecasting techniques*	3	2	-
CLO-3 :	*able to develop an optimization model for energy planning*	3	2	-
CLO-4 :	*equip to write project proposals and cost estimation.*	2	-	-
CLO-5 :	*acquire knowledge of national and state energy policies*	2	2	-

Module-1 - Energy Scenario	***9 Hour***
Role of energy in economic development and social transformation: Energy & GDP, GNP and its dynamics. Energy Sources and Overall Energy demand and Availability, Energy Consumption in various sectors and its changing pattern, Status of Nuclear and Renewable Energy: Present Status and future prospectus – national and international levels.	
Module-2 - Forecasting Models	***9 Hour***
Forecasting Techniques, Regression Analysis, Double Moving Average, Double Experimental Smoothing, Triple Exponential Smoothing, ARIMA model, Validation techniques and methods, Qualitative forecasting, Delphi technique, Concept of Neural Networks.	
Module-3 – Optimization Models	***9 Hour***
Principles of Optimization, Formulation of Objective Function, Constraints, Multi-Objective Optimization, Mathematical Optimization Softwares, Development of Energy Optimization Model, Development of Scenarios, Sensitivity Analysis, Concept of Fuzzy Logic.	
Module-4 – Project Management	***9 Hour***
Project Preparation, Feasibility Study, Detailed Project Report, Project Appraisal, Social-cost Benefit analysis, Project Cost Estimation, Project Risk Analysis and management, Project Financing, Financial evaluation and reporting. Case studies models	
Module-5 – Energy Policy	***9 Hour***
Importance and need for energy policy, National & State Level Energy Issues, National and State Energy Policy - Energy Security – National solar mission - state solar energy policy - Framework of Central Electricity Authority (CEA), Central and States Electricity Regulatory Commissions (CERC & ERCs).	

Learning Resources	1. Armstrong J.Scott, 'Principles of forecasting: a hand book for researchers and practitioners', Norwell, Massachusetts: Kluwer Academic Publishers.2001. 2. Dhandapani Alagiri, 'Energy Security in India Current Scenario', The ICFAI University Press,2006. 3. Rob J Hyndman, Forecasting: Principles and Practice, OTexts, 3rd Ed., 2021 4. Spyros G. Makridakis, Steven C. Wheelwright, Rob J. Hyndman, 'Forecasting Methods and applications', Wiley, 3rd ed., 1998.	5. Sukhvinder Kaur Multani, 'Energy Security in Asia Current Scenario', The ICFAI University Press, 2008. 6. Yang X.S., 'Introduction to mathematical optimization: From linear programming to Metaheuristics', Cambridge, Int. Science Publishing, 2008. 7. Durai Pravin, Principles of Management, Pearson Education India, 2015

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	20%	-	20%	-	20%	-
Level 4	Analyze	20%	-	20%	-	20%	-
Level 5	Evaluate	20%	-	20%	-	20%	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Soumitra Mukhopadhyay, SMS India Pvt. Ltd, Kolkatta	1. Dr. Ravita Lamba, MNIT Jaipur	1. Dr. R. Senthil, SRM IST
2. Mr. M. Periyasamy, NLC India, Neyveli	2. Dr. G. Kumaresan, Anna University Chennai	2. Dr. P. Balakrishnan, SRM IST

Course Code	21MEE538T	Course Name	SOLAR ENERGY FOR INDUSTRIAL PROCESSES AND AGRICULTURE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	**Data Book / Codes/Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1 :	*gain the knowledge of the importance of solar energy in agriculture*
CLR-2 :	*familiarize with the different solar energy systems used in agriculture applications*
CLR-3 :	*gain the knowledge of the importance of solar energy in industrial applications*
CLR-4 :	*familiarize with the different solar energy systems used in industrial processes*
CLR-5 :	*acquire expertise in the economic and environmental aspects of using solar energy*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CLO-1 :	*familiarize with the solar energy systems in agriculture*	3	1	-
CLO-2 :	*comprehend the different solar energy systems for agriculture applications*	3	2	-
CLO-3 :	*familiarize with the importance of solar energy for industrial processes*	3	2	-
CLO-4 :	*analyze the importance of solar energy systems in industrial processes*	3	2	-
CLO-5 :	*identify the economic and environmental impacts of solar energy agriculture / industrial processes*	3	1	-

Module-1 - Introduction to Solar Energy in Agriculture	***9 Hour***
Overview of Solar Energy and Its Relevance to Agriculture - Historical Perspectives and Developments -Importance of Renewable Energy in Agriculture - Basics of Solar Photovoltaic (PV) Technology - Components of PV Systems: Modules, Inverters, Batteries - Design and Sizing of Solar PV Systems for Agriculture	
Module-2 – Applications of Solar Energy in Agriculture	***9 Hour***
Importance of Water Pumping in Agriculture - Solar Water Pumping Technology - Design Considerations and Case Studies - Solar Dryers: Principles and Types - Applications of Solar Drying in Agriculture - Case Studies on Solar Dehydration- Introduction to Precision Agriculture - Use of Drones and Sensors - Integration of Solar Technologies in Precision Agriculture - Solar Greenhouses: Design and Technology - Controlled Environment Agriculture - Agrovoltaics	
Module-3 - Introduction to Solar Energy for Industrial Processes	***9 Hour***
Overview of Solar Energy and Its Importance in Industry - Comparison of Solar Technologies: Photovoltaic vs. Solar Thermal - Applications of Solar Energy in Industrial Processes - Principles of Solar Thermal Technology - Types of Solar Thermal Collectors: Flat-plate, Concentrating - Applications of Solar Thermal in Industry: Heating, Cooling, Steam Generation	
Module-4 - Applications of Solar Energy in Industrial Process	***9 Hour***
Solar Steam Generation: Concentrated Solar Power (CSP) Systems - Solar Desalination Technologies - Applications of Solar Desalination in Industry - Solar Water Treatment Systems for Industrial Processes - Solar Cooling Technologies: Absorption Chillers, Adsorption Chillers - Applications of Solar Cooling in Industrial Processes - Design and Sizing of Solar Cooling Systems - Thermal Energy Storage Systems - Batteries and Energy Storage for Solar PV Systems - Integration of Energy Storage in Industrial Processes	
MODULE-5 – Economic and Environmental Aspects	***9 Hour***
Cost-Benefit Analysis of Solar Technologies in Agriculture - Government Policies and Incentives - Financing and Funding Opportunities for Solar Agricultural Project - Cost-Benefit Analysis of Solar Energy Systems in Industry - Environmental Benefits and Carbon Footprint Reduction - Government Policies, Incentives, and Financing Options - Maintenance Requirements for Solar Systems - Performance Monitoring and Analysis	

Learning Resources		
Learning Resources	1. *Ibrahim Dincer and Marc A Rosan, Thermal Energy Storage: Systems and Applications, John Wiley, 2003.* 2. *Sukhatme and Nayak, Solar Energy: Principles Of Thermal Collection & Storage, Tata McGrawHill, 2008* 3. *John A. Duffie, William A. Beckman : Solar Engineering of Thermal Processes, Wiley, 2013*	4. *Roger A. Messenger, Amir Abtahi: Photovoltaic Systems Engineering, CRC Press, 2017* 5. *Vaughn C. Nelson, Kenneth L. Starcher, CRC Press, 2016*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	20%	-	20%	-	20%	-
Level 2	*Understand*	20%	-	20%	-	20%	-
Level 3	*Apply*	20%	-	20%	-	20%	-
Level 4	*Analyze*	20%	-	20%	-	20%	-
Level 5	*Evaluate*	20%	-	20%	-	20%	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Shaji Sidney, Research and Development, Tan90 Thermal Solution Private Limited, 600 097, Chennai, India	*1. Dr. Rajendran Prabakaran,International Research Professor, Yeungnam University, South Korea.*	*1. Dr. M. Sivashankar, SRM IST*
2. Dr. Anto Joseph Deeyoko L, Sustainability Expert, Renewable Cogen Globe Energy, Environment & Climate Change (RCG - EECC) Division, Chennai, India	*2. Dr. Santosh Ravichandran, Research Associate, Desalination and Separations Group, Los Alamos National Laboratory, Los Alamos, New Mexico, USA 87545.*	*2. Dr. Joji Johnson, SRM IST*

Course Code	21MEE631T	Course Name	INSTALLATION AND MAINTENANCE OF SOLAR SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*familiarize with electrical circuit for photovoltaic system*
CLR-2:	*gain the knowledge of the components of a photovoltaic system*
CLR-3:	*gain the knowledge to design a photovoltaic system*
CLR-4:	*acquire expertise in the safe installation of the photovoltaic system*
CLR-5:	*familiarize with the maintenance of a photovoltaic system*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*familiarize with the basic electrical and electronics circuit components and solar photovoltaic panels*	3	-	-
CO-2:	*analyze the working of Batteries, Charge Controller, MPPT, Inverter and BOS*	3	-	-
CO-3:	*design a solar photovoltaic power plant*	3	-	3
CO-4:	*comprehend site selection and installation and apply health and safety practices at the workplace*	3	2	-
CO-5:	*apply the various maintenance techniques for the smooth functioning of a PV power plant*	3	2	-

Module-1 – Basic Principles of Electricity and Solar Photovoltaic System	***9 Hour***
Fundamentals of Electricity - Basic Laws in Electrical Installations - Ohm's Law - Kirchhoff's Voltage Law - Kirchhoff's Current Law - Series and parallel electrical circuit connections – Multimeter - Clamp Meter - Concept of Solar PV Module, Panel and Array -Technical specifications of a solar panel - Size and power rating of a solar panel - Standard Test Condition (STC) and Capacity Utilization Factor (CUF) in solar panel performance assessment – Electrical block diagram of a solar PV system.	
Module-2 – Batteries, Charge Controller, MPPT, Inverter and BOS	***9 Hour***
Types of Batteries - Battery parameters - How to select Batteries - Batteries for Photovoltaic Systems - C-Rating, Depth of Discharge (DOD), State of Charge (SOC), and cycle life of Batteries in Solar PV System - AC to DC Converter - DC to AC Converter - DC to DC power converter - Charge Controller - Maximum Power Point Tracking - Junction box - Standalone inverter – Miniature Circuit Breaker (MCB) - Earth Leakage Circuit Breaker (ELCB) - Molded Case Circuit Breaker (MCCB).	
Module-3 - Solar PV System Design and Integration	***9 Hour***
Types of Solar PV Systems - Design methodology for SPV system – Feasibility Study for solar systems - Series and parallel configurations - Selection of Cables & Wires - Techniques for Crimping of Lugs/Ties/Cable Glands/ MC4 Connector - Earthing for AC/DC system and Lightening Arrestor - Power Evaluation & Connection - Structural integrity and efficient electrical connections - Mechanical structure design - Mounting structures for solar panel Installations - RCC Roof (Ballast Type) - Tin Shade (Flush Mounted) - Elevated Structure - Ground Mounted (Fixed Tilt) - Significance in solar panel orientation - Set the tilt angle of solar panels for maximum efficiency – Estimate of Energy production using PVsyst – Project Management principles for solar power plants.	
Module-4 - Installing, Trouble Shooting and Safety	***9 Hour***
Perform site selection - Load requirement of a household/grid - Nature of load (AC or DC) connected to solar PV System - Installation and Troubleshooting of Standalone Solar PV System, Solar Street Light and Solar Lantern - Maintenance of Solar PV System - Basic safety and hazards - Safety in the installation of Solar PV System - Health and safety practices at the workplace - Safety procedures for maintaining electrical safety, handling tools and hazardous materials - Work ethics and workplace etiquette - Electrical Audit.	
Module-5 – Maintenance of PV Power Plant	***9 Hour***

Type of maintenance - Preventive, Periodic and Regular maintenance – Cleaning - Visual Inspection - Electrical checks - Shade Management - Battery maintenance - Remote Monitoring Systems - Warranty and Repair - Safety Considerations - Solar Panel Recycling - Waste management and methods of disposing hazardous waste.

Learning Resources	1. *Stuart R.Wenham, Martin A. Green, Muriel E. Watt and Richard Corkish, 'Applied Photovoltaics', Earthscan, UK, 2007.* 2. *Chetan Singh Solanki, 'Solar Photovoltaic Technology and Systems' – A Manual for Technicians, Trainees and Engineers, PHI, 2014.* 3. *Garg H.P., Prakash J., Solar Energy Fundamentals and Applications, Tata McGraw-Hill, 2005.*	4. *Solanki, Chetan Singh. Solar photovoltaics: fundamentals, technologies and applications. PHI Learning Pvt. Ltd., 2015.* 5. *Mertens, Konrad. Photovoltaics: fundamentals, technology, and practice. John Wiley & Sons, 2018.* 6. *International Electrotechnical Commission (IEC) - TC 82 - Solar photovoltaic energy systems (Available online)*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*30%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*30%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	*20%*	-	*20%*	-	*20%*	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Daniel Gnanaselvam, CEO, Brighter Green Universal Engineering.	*1. Dr. Ravita Lamba, MNIT Jaipur*	*1. Dr. Joji Johnson, SRMIST.*
2. Mr. Sijith K, Director, Milan & Spire Energy.	*2. Dr. G. Kumaresan, Anna University, Chennai*	*2. Dr. V. Mathanraj, SRMIST.*

Course Code	21MEE632T	Course Name	FUZZY LOGIC AND NEURAL NETWORK FOR SOLAR ENERGY SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	**Data Book / Codes/Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1 :	*be familiar with the architecture of intelligent control for solar energy systems*
CLR-2 :	*know the concept of artificial neural network*
CLR-3 :	*familiarize the concept of diverse materials used for solar devices*
CLR-4 :	*know the concept of genetic algorithm*
CLR-5 :	*familiarize with various fuzzy logic concepts in solar energy applications.*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CLO-1 :	*understand the approaches of intelligent control for solar energy systems*	3	-	-
CLO-2 :	*understand the concept of artificial neural networks and its methods*	3	2	-
CLO-3 :	*comprehend fuzzy logic systems and operation principles*	3	2	-
CLO-4 :	*analyze genetic algorithms using various techniques*	2	-	-
CLO-5 :	*apply the various fuzzy logic concepts in applications*	3	2	-

Module-1 - Introduction	***9 Hour***
Approaches to intelligent control. Architecture for intelligent control. Symbolic reasoning system, Rule-based systems, the AI approach. Knowledge representation. Expert systems using AI and Machine Learning.	
Module-2 - Artificial Neural Networks	***9 Hour***
Concept of Artificial Neural Networks and its basic mathematical model, McCulloch-Pitts neuron model, simple perceptron, Adaline and Madaline, Feed-forward Multilayer Perceptron. Learning and training the neural network. Data Processing: Scaling, Fourier transformation, principal-component analysis and wavelet transformations. Hopfield network, Self-organizing network and Recurrent network. Neural Network based controller.	
Module-3 - Fuzzy Logic System	***9 Hour***
Introduction to crisp sets and fuzzy sets, basic fuzzy set operation and approximate reasoning. Introduction to fuzzy logic modeling and control. Fuzzification, inferencing and defuzzification. Fuzzy knowledge and rule bases. Fuzzy modeling and control schemes for nonlinear systems. Self-organizing fuzzy logic control. Fuzzy logic control for nonlinear time-delay system.	
Module-4 - Genetic Algorithm	***9 Hour***
Basic concept of Genetic algorithm and detail algorithmic steps, adjustment of free parameters. Solution of typical control problems using genetic algorithm. Concept on some other search techniques like tabu search and ant-colony search techniques for solving optimization problems.	
Module-5 – Applications	***9 Hour***
GA application to power system optimization problem, Case studies: Identification and control of linear and nonlinear dynamic systems using MATLAB-Neural Network toolbox. Stability analysis of Neural-Network interconnection systems. Implementation of fuzzy logic controller using MATLAB fuzzy-logic toolbox. Stability analysis of fuzzy control systems.	

Learning Resources		
Learning Resources	1. *Timothy J. Ross, Fuzzy Logic with Engineering Applications, Wiley 2011.* 2. *Dan W. Patterson, Introduction to Artificial Intelligence and Expert Systems, PHI Learning,2009.* 3. *Laurene Fausett, Fundamentals of Neural Networks, Pearson Education India, 2006.*	4. *Russell, Artificial Intelligence, Pearson Education India, 2003.* 5. *S. Rajasekaran, G. A. Vijayalakshmi Pai, " Neural Networks, Fuzzy Systems and Evolutionary Algorithms: Synthesis and Applications ", PHI Learning, 2nd edition, 2017.* 6. *Howard B Demuth, Mark H Beale, Orlando de Jesus, "Neural Network Design", 2Nd edition, Martin Hagan, 2014.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	20%	-	20%	-	20%	-
Level 2	*Understand*	20%	-	20%	-	20%	-
Level 3	*Apply*	20%	-	20%	-	20%	-
Level 4	*Analyze*	20%	-	20%	-	20%	-
Level 5	*Evaluate*	20%	-	20%	-	20%	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Shaji Sidney, Research and Development, Tan90 Thermal Solution Private Limited, 600 097, Chennai, India	*1. Dr. S. VinothKumar, Associate Professor, Shandong University, China.*	*1. Dr. P. Ganeshkumar, SRM IST*
2. Dr. Anto Joseph Deeyoko L, Sustainability Expert, Renewable Cogen Globe Energy, Environment & Climate Change (RCG - EECC).	*2. Dr. Santosh Ravichandran, Research Associate, Desalination and Separations Group, Los Alamos National Laboratory, Los Alamos, New Mexico, USA.*	*2. Dr. P. Sundaram, SRM IST*

Course Code	21MEE634T	Course Name	SOLAR POWER GENERATION TECHNIQUES AND POLICIES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co-requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes/Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*familiarize with solar radiation and flat plate collectors*
CLR-2 :	*analyze the performance of solar power towers*
CLR-3 :	*analyze the performance of parabolic trough technology*
CLR-4 :	*analyze of the linear Fresnel reflector technology*
CLR-5 :	*analyze and study of hindrance in implementing solar policies.*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	*Program Outcomes (PO)*		
		1	***2***	***3***
CLO-1 :	*comprehend the design aspects of solar flat plate thermal collectors*	3	-	-
CLO-2 :	*examine the performances of solar power towers*	3	2	-
CLO-3 :	*examine the performance of parabolic trough technology*	3	2	-
CLO-4 :	*examine the performance of linear Fresnel reflector technology*	2	-	-
CLO-5 :	*examine the policies in solar energy sector in India and world*	3	2	2

Module-1 – Flat Plate Collectors	***9 Hour***
Introduction to solar energy, Fundamentals of solar radiation, Fundamentals of solar collectors, Classifications of solar collectors, Construction details of solar collectors, Flat plate air heaters, Box type solar cookers, Design and structures of collectors for heating liquids, Design and structures of collectors for air heating.	
Module-2 – Solar Power Towers	***9 Hour***
Concentrating collectors, Point focusing techniques, Design of solar field and calculation of losses, Classification of volumetric absorbers, Open and closed volumetric air receivers, Heat transfer fluid, Energy balance in the volumetric absorbers, Energy storage in solar power tower technology, Applications of solar power tower technology. Case studies on Solar Power Towers and solar furnaces.	
Module-3 – Parabolic Trough Technology	***9 Hour***
Single and dual axes tracking system, Design of evacuated tube collectors, Energy balance on evacuated tube, Parabolic trough solar collectors, Types, procedures and challenges in dual-axis tracking Systems, Energy storage through parabolic trough technology, Applications of parabolic trough technology.	
Module-4 - Linear Fresnel Reflector Technology	***9 Hour***
Introduction of Linear Fresnel Reflector (LFR), LFR for water purification and power production, Performance analysis, Energy and Exergy analysis, Case studies on LFR.	
Module-5 – Policies for Solar Power Generation	***9 Hour***
Legislations guiding solar energy sector, National & State Energy Policy, Jawaharlal Nehru National Solar Mission (JNNSM), Regulations regarding grid interconnected solar energy systems, Solar Energy policy – 2021, solar energy policies in different countries, Challenges and strategies in implementing solar energy policies, Case study analysis.	

Learning Resources	*1.Soteris A.Kalogiru, "Solar Energy Engineering: Processes and systems", 1st edition, Academic press, 2009.* *2.Sukhatme .K, Suhas P.Sukhatme., "Solar energy: Principles of thermal collection and storage", Tata McGraw Hill publishing Co. Ltd, 8th edition, 2008.* *3.Duffie .J. A & Beckman .W.A, "Solar Engineering of Thermal Processes", 3rd edition, John Wiley & Sons, Inc., 2006.* *4.Garg .H.P,Prakash .J, "Solar energy fundamentals and applications", Tata McGraw Hill publishing Co. Ltd, 2006.*	*5. Yogi D. Goswami, Frank Kreith, Jan F.Kreider., "Principle of solar engineering", 2nd edition, Taylor and Francis, 2nd edition, 2003.* *6.Green MA. Solar cells: Operating principles, technology, and system applications. Englewood Cliffs, NJ, Prentice-Hall, Inc., 2009.* *7.P. Meier and M. Munasinghe: Energy Policy Analysis & Modeling, Cambridge University Press,*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	*20%*	-	*20%*	-	*20%*	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Amit Gupta, ABSTC, Mumbai	*1. Dr. Laltu Chandra, IIT Kanpur*	*1. Dr. Piyush Sharma, SRM IST*
2. Dr. Sanjeev Rana, JSP, Raigarh, Chhattisgarh	*2. Dr. Gurveer Singh, MANIT Bhopal*	*2. Dr. T. Lakshmanan, SRM IST*

ACADEMIC CURRICULA

Solar Energy and Thermal Engineering

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21MEE535T	Course Name	ADVANCED ENERGY STORAGE	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co-requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	***Data Book / Codes/Standards***	*Advanced Energy Storage databook*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1 :	*familiarize with various forms of energy storage*
CLR-2 :	*be familiar with the modeling of sensible heat storage*
CLR-3 :	*know the concepts and modeling of LHTES systems*
CLR-4 :	*Know the concepts of electrical and electrochemical energy storage*
CLR-5 :	*familiarize with the applications of thermal energy storage*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Program Outcomes (PO)***		
		1	***2***	***3***
CLO-1 :	*Identify the need and various forms of energy storage*	3	-	-
CLO-2 :	*Analyze the various models used in sensible heat storage systems*	3	-	-
CLO-3 :	*Analyze the various models used in latent heat storage systems*	3	-	-
CLO-4 :	*Comprehend electrical and electrochemical energy storage principles*	3	-	-
CLO-5 :	*Identify the concepts of thermal storage for various applications*	3	--	

Module-1 - Various forms of Energy Storage	***9 Hour***
Thermal energy storage scenario in India and Global level. Types of energy storage mechanical, chemical, electrical, magnetic, hydrogen, biological medium. Thermal energy storage technologies, need for TES, types of TES, Sensible and latent heat storage material- Classification, Thermo physical properties, selection criteria. Heat transfer fluid – Classification, Thermo physical properties, selection criteria. Case studies on material characterization for thermal storage mediums.	
Module-2 - Modeling of Sensible Heat Storage	***9 Hour***
Single-blow operating model - Infinite fluid heat capacity, negligible temperature gradient in storage material, internal temperature gradient in storage material, Simplified model, Finite conductivity model-slab configuration, Finite conductivity model - hollow cylinder configuration, comparisons of finite conductivity models of hollow cylindrical and slab configurations, Analysis of the effects of finite thermal conductivity, Design of sensible heat thermal energy storage system and case studies on sensible heat storages.	
Module-3 - Modeling of LHTES Systems	***9 Hour***
Modeling of phase change problems, Temperature based model, Enthalpy based model, Porous medium approach, Conduction dominated phase change model, Apparent heat capacity model, Heat transfer with phase change in simple geometries, Packed beds models, Thermal stratification.	
Module-4 – Electrical, Electrochemical and Biogas Energy storage	***9 Hour***

Fundamental concept of batteries, measuring of battery performance, charging and discharging of a battery, storage density, energy density, and safety issues, Types of batteries–Lead Acid, Nickel-Cadmium, Modern batteries, Fuel Cell – types, Case study in electrical energy storage, Principles of Electrochemical storage, Hydrogen - Compressed gas and liquid hydrogen, Metal hydrides, Case study in electrochemical energy storage, Biogas energy storage and applications.
Module-5 –Thermal Energy Storage Applications **9 Hour**
Comparison of storage technologies ,Cool storage concept -, Cool thermal storage in process cooling applications, Cool thermal storage in building air conditioning systems, Solar energy storage – Passive heating and cooling, Green house heating, Drying and heating for process industries, Solar power plant applications, Sustainable thermal storage systems-types, Low energy and low carbon thermal storage, Geothermal energy storage and Wind thermal cold energy storage, Hybrid TES and CHP thermal storage, Case studies on hybrid energy storage.

Learning Resources	1. *Ibrahim Dincer and Marc A. Rosen, "Thermal Energy Storage Systems and Applications", 2nd Edition, John Wiley and Sons Ltd., 2011.* 2. *Electrochemical technologies for energy storage and conversion, Ru-shiliu, Leizhang, Xueliangsun,Wiley publications, 2012* 3. *Fuel cell systems Explained, James Larminie and Andrew Dicks, Wiley publications, 2003* 4. *Luisa F.Cabeza, "Advances in Thermal Energy storage systems, Methods and applications", Wood head Publishing,Elsevier,2015* 5. *S.Kalaiselvam and R.Parameshwaran., "Thermal Energy Storage Technologies for sustainability systems Design, assessment and Applications", Elsevier publications ,2014*	6. *Frank W. Schmidt, A. John Willmott, "Thermal Energy Storage and Regeneration", Hemisphere Publishing Co., 1981.* 7. *Charles E. Dorgan, James S. Elleson, "Design Guide for Cool Thermal Storage", ASHRAE, Atlanda, 1993.* 8. *G. Beckmann, "Thermal Energy Storage: Basics, Design, Applications to power generation and heat supply", Springer, 1984* 9. *ASHRAE, "Handbook of Fundamentals", American Society of Heating Refrigeration and Air conditioning Engineers, New York, 2000*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	30%	-
Level 2	Understand	30%	-	30%	-	30%	-
Level 3	Apply	20%	-	20%	-	20%	-
Level 4	Analyze	20%	-	20%	-	20%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Dr. Soumitra Mukhopadhyay, SMS India Pvt. Ltd, Kolkatta*	1. *Dr. Ravita Lamba, MNIT Jaipur*	1. *Dr.D.Premnath, SRMIST*
2. *R. M. Periyasamy, NLC India, Neyveli*	2. *Dr. G. Kumaresan, Anna University Chennai*	2. *Dr.R.Senthil, SRMIST*

Course Code	21MEE536J	Course Name	MODELLING AND ANALYSIS OF ENERGY SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*Mechanical Engineering*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*acquire knowledge on various mathematical techniques*
CLR-2:	*be familiar with various numerical techniques*
CLR-3:	*examine the unconstrained problems*
CLR-4:	*be familiar with various economic models*
CLR-5:	*acquire knowledge on numerical solution of DE*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*understand and apply the step-in model development*	3	-	-
CO-2:	*identify the different method of solution for nonlinear algebraic equations*	3	-	-
CO-3:	*analyze the unconstrained and constrained problems*	3	-	-
CO-4:	*apply optimization in energy system*	3	-	-
CO-5:	*understand and apply different solution technique for energy system*	3	-	-

Module-1 - Modelling Overview	***9 Hour***
Levels of analysis – steps in model development-examples of models – quantitative techniques – interpolation –polynomial– Lagrangian – curve fitting – regression analysis –solution of transcendental equations. Case studies on regression analysis.	
Module-2 - Systems Simulation	***9 Hour***
Information flow diagram – solution of set of nonlinear algebraic equations – successive substitution – Newton Raphson – examples of energy systems simulation.	
Module-3 - Optimization	***9 Hour***
Objectives/constraints – problem formulation –unconstrained problems – necessary and sufficiency conditions, Constrained optimization, Case studies on optimization techniques.	
Module-4 Dynamic Programming	***9 Hour***
Search Techniques – univariate and multivariate –case studies of optimization in energy systems Dealing with uncertainty- probabilistic techniques – Trade-offs between capital and energy using Pinch analysis, Case studies on dynamic programming.	
Module-5 Energy- Economy Models	***9 Hour***
Scenario generation – input output model, Numerical solution of differential equations – overview – convergence –accuracy – transient analysis – application examples, Case studies on energy-economic models	

Learning Resources	1. *W. F. Stoecker, Design of Thermal Systems, McGraw Hill, 1981.* 2. *Vanek F.M., Albright L.D. Energy Systems Engineering, McGraw-Hill, 2008.*	3. *S. S. Rao, Optimization theory and applications, Wiley Eastern, 1990.* 4. *Vogel. W, Kalb. H, "Large- Scale Solar Thermal Power Technologies", WileyVCH, 2010*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 Practice (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	-	-	*30%*	-
Level 2	*Understand*	*30%*	-	-	*30%*	*30%*	-
Level 3	*Apply*	*20%*	-	-	*30%*	*20%*	-
Level 4	*Analyze*	*20%*	-	-	*20%*	*20%*	-
Level 5	*Evaluate*	-	-	-	*20%*	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. Parag Deshpande, senior scientist, NAL	*1. Dr Aviansh Kumar IITDM Kancheepuram*	*1. Dr. Santosh Kumar Singh, SRMIST*
2. Dr. A.Velayutham, DRDO, Avadi, velayudham.a@cvrde.drdo.in	*2. Dr. Vihnu M Teja IIT ISM Dhanbad*	*2. Dr. M. Gunasekaran, SRMIST*

Course Code	21MEE633J	Course Name	MEASUREMENT TECHNIQUES IN ENERGY SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	Mechanical Engineering	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn the basic concepts of measuring systems*
CLR-2:	*understand the concept of dynamic responses*
CLR-3:	*learn different measurement techniques in fluid dynamics*
CLR-4:	*possible applications of measuring techniques*
CLR-5:	*understand the concept of Data Acquisition System (DAQ) and post processing*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	***Programme Outcomes (PO)***		
		1	***2***	***3***
CO-1:	*explain the basic concepts of measuring systems*	3	2	-
CO-2:	*discuss the concept of dynamic responses*	3	2	-
CO-3:	*analyze different measurement techniques in fluid dynamics*	3	2	--
CO-4:	*apply the concept of measurement techniques*	3	-	1
CO-5:	*apply the concept of Data Acquisition System (DAQ) and post processing*	3	2	-

Module-1 - Introduction to Measurement Systems	***12 Hour***
General measuring system and their concepts, Static and Dynamic response of measuring systems, Basic methods of measurement, Functional Elements of Measurement Systems, Error analysis– Statistical methods, Measurement errors, Probability distributions, Curve fitting and Signal conditioning, Discretization, and analysis.	
Module-2 - Dynamic Response of Instruments	***12 Hour***
Dynamic performance characteristics, Types of standard input signals, Instrument types –Zero and higher order instruments, First order and second order instrument, Step response and Ramp response of first order system, Impulse response, Frequency response for First and Second order instruments, Response of a general form of instrument to a periodic input, Time and frequency domain specifications, Detailed analysis on measurement system parameters.	
Module-3 - Measurement Techniques	***12 Hour***
Pressure measurement- Manometers, Barometer, Dead weight testers, and Mechanical load gauge, Mechanical pressure transducers- Bourdon tube, Bellows and Capsule, Diaphragm, Electrical pressure transducers – Piezometer, Capacitance, Resistance – Potentiometers, Strain-gauge, LVDT, Piezoelectric transducers and Differential pressure devices, Temperature measurement: Liquid in Glass Thermometer, Gas Thermometer, Velocity Measurement: Hot-wire/Hot-Film & Cold-Wire/Cold-Film Anemometry, Laser Doppler velocimetry, Full-field (2-D) Quantitative imaging techniques like PIV& PLIF	
Module-4 Applications	***12 Hour***
Flow measurements: Obstruction meters – Venturi-meter and Orifice meter, Flow nozzle, Laminarize flow meter and Elbow meter, Pitot tube, Sonic nozzle, Rotameter, Tangent flow meter, and Turbine flow meter, Vortex flow meter, Positive-displacement flow meter, Mass flow meter: Thermal mass flow meter, and Corolis mass flow meter, Hot wire anemometer, Optical Density Based Techniques – Schlieren, Shadowgraph, Strain gauge – Calibration.	

Module-5 Data Acquisition System (DAQ)	***12 Hour***
Types of Data Acquisition Systems (DAQ), Configuration of DAQ, Signal conditioning, A/D, D/A conversions and Sampling concept, Introduction to digital signal processing Filters, Post processing tools, Case study: Measurement of flow rate using turbulent flow meter, Measurement of pressure using pressure transducer, Measurement of pressure loss in water tunnel, Measurement of temperature using Datalogging system - Agilent	

Learning Resources	1. *Tavoularis, Stavros. Measurement in fluid mechanics. Cambridge University Press, 2005.* 2. *Beckwith, Thomas G., Nelson Lewis Buck, and Roy D. Marangoni. Mechanical measurements. Vol. 5. New York: Addison-Wesley, 1982.*	3. *Doebelin, Ernest O., and Dhanesh N. Manik. "Measurement systems: application and design." (2007).* 4. *Holman, Jack Philip. "Experimental methods for engineers." (1966).* 5. *J. Anthoine, "Measurement Techniques in Fluid Dynamics: An Introduction" Von Karman Institute for Fluid Dynamics, 2009..*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	-	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*20%*	-	-	*20%*	*20%*	-
Level 4	*Analyze*	*20%*	-	-	*30%*	*20%*	-
Level 5	*Evaluate*	*20%*	-	-	*30%*	*20%*	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Jayachandran Murugesan, Deputy Manager - Technology & Innovation Thermax Limited, Chennai, India	*1. Dr. V. Kumaresan, Anna University, Chennai.*	*1. Dr. K. Suresh Kumar, SRMIST*
2. Mr. Babu P, Head of Innovation at Thermax Limited, India	*2. Dr. A. Gurubalan, IIT Bombay, Mumbai*	*2. Dr. A. Sathishkumar, SRMIST*