Maulana Abul Kalam Azad University of Technology, West Bengal
(Formerly West Bengal University of Technology)
Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Curriculum Structure

MAKAUT												
TEACHING AND EXAMINATION SCHEME FOR M.TECH COURSE												
COURSE NAME: RENEWABLE ENERGY												
COURSE CODE : MRE												
DURATION OF COURSE : 2 YEARS												
SEMESTER:FIRST SEMESTER						SCHEME :						
Sr. No.	SUBJECT Code	SUBJECT	PERIODS			EVALUATION SCHEME						Credits
THEORY			L	T	P	SESSIONSAL EXAM			ESE	PR (I NT.)	PR (EX T.)	
						TA	CT	Total				
1	MRE101	Energy Resources	02	01	--	15	15	30	70	--	--	3
2	MRE102	Renewable Energy I	02	01	--	15	15	30	70	--	--	3
3	MRE103	Renewable Energy II	02	01	--	15	15	30	70	--	--	3
4	MRE104	Nuclear Energy	02	01	--	15	15	30	70			3
5	MRE105	Power system analysis	02	01	--	15	15	30	70	--	--	2
6	MRE106	Safety & Disaster Management	02	01	--	15	15	30	70	--	--	2
7	MRE107I/II/ III	Industrial Energy Analysis/Waste to Energy/Energy Storage	02	01		15	15	30	70	--	--	0
8	MRE191	Energy Technology Lab	--	--	04	--	--	--	--	50	50	2
9	MRE192	Power Laboratory	--	--	04	--	--	--	--	50	50	2

STUDENT CONTACT HOURS PER WEEK: 30
THEORY AND PRACTICAL PERIODS OF 60 MINUTES EACH

ABBREVIATIONS: CT- Class Test, TA - Teachers Assessment, L - Lecture, T - Tutorial, PR (INT.) – Practical (Internal) PR(EXT.)- Practical(External), ESE - End Semester Exam.

TA: Attendance & surprise quizzes = 6 marks. Assignment & Group Discussion = 4 marks.

Minimum passing for sessional marks is 40%, and for theory subject 40%.

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Name of the Course: M. Tech in Renewable Energy **Subject: Energy Resources**	
Course Code: MRE 101	**Semester: 1**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs/wk	End Semester Exam: 70
Tutorial: 1 hr/wk	Teacher's Assessment: 15
Practical:	Internal Assessment: 15
Credit: 3	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Aim:

Sl. No.	
1.	This subject find utility in understanding concepts & gather knowledge about the different conventional energy resources available in earth.

Objective:

Sl. No.	The students will able
1.	Gather knowledge of conventional fossil fuels.
2.	Learn different characterization techniques of solid, liquid and gaseousfuel.
3.	Understand different strategies of combustiontechnology.

Pre-Requisite:

Sl. No.	
1.	Chemical reaction balancing
2.	Atomic & molecular properties of different substances.

Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours /Unit**	**Marks**
01	**Solid Fuels:**	**12**	**20**

	Conventional (fossil) and non-conventional (alternative resources and reserves) energies. Global energy production and consumption pattern and Indian pattern, Classification of fuels, Calorific value. Solid Fuels: Coal, Biomass, Wood, Charcoal, Classification and rank of Coal, Coalreserves in India, physical properties of Coal: proximate and ultimate analysis of Coal ,Cleaning, washing,Pulverisation & briquetting of Coal, Storage ofCoal. Theory of Coal Pyrolysis: LTC and HTC process, Coke oven-Beehive and by product Slot type Coke ovens. Recovery of by products Coal Chemicals, operation and Design of Coke ovens		
02	**Liquid Fuels:** Origin of Crude oil, Constitutions of Crude oil, Characterization of Crude oil, drilling of Petroleum, fractionation of Crude oil in refineries ,Thermal & Catalytic cracking and catalytic reforming processes, Coking, fluidized bed cracking. Properties and Testing logistic of petroleum products: Octane number, Cetane No, pour point, fire point, flash point, aniline point, Carbon residue, liquid fuel by Fischer-Tropsch process , IS specification of gasoline ,kerosene, Diesel and fuel oils.	**12**	**20**
03	**Gaseous fuels:** Classification of gaseous fuels, producer gas, blue and carbureted water gas, Coal gas, Blast furnace gas, natural gas, Coal bed methanes, LPG & CNG. Bio gas: Principles and operation of aerobic and anaerobic digesters, Biogas generation, Flow sheet with reference to waste utilization.	**12**	**15**
04	**Combustion Process:** Combustion stoichiometry, Combustion thermodynamic- problems, Kinetics of combustion, Combustion appliances	**12**	**15**
	Sub Total:	**40**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**

List of Books

Text Books/ Reference Books:

Maulana Abul Kalam Azad University of Technology, West Bengal
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Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
Dr. Samir Sarkar.	Fuels and combustion (3rd Edition)-		
OP Gupta	Elements of fuel, furnaces and Refractories		Khanna Publishers, University Press.
Brame & King.	Fuel and Furnace		

End Semester Examination Scheme. **Maximum Marks-70.** **Time allotted-3hrs.**

Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)		**Subjective Questions**			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

- Only multiple choice type question (MCQ) with one correct answer are to be set in the objective part.
- Specific instruction to the students to maintain the order in answering objective questions should be given on top of the question paper.

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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course: M. Tech in Renewable Energy **Subject: Renewable Energy I**			
Course Code: MRE 102		**Semester: 1**	
Duration: One Semester		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 2 hrs/wk		End Semester Exam: 70	
Tutorial: 1 hr/wk		Teacher's Assessment: 15	
Practical:		Internal Assessment: 15	
Credit: 3		Practical Sessional internal continuous evaluation:	
		Practical Sessional external examination:	
Aim:			
Sl. No.			
2.	This subject find utility in understanding concepts & gather knowledge about the different aspects, theories, applications and future prospects of solar energy.		
Objective:			
Sl. No.	The students will able		
4.	To gather knowledge of different solar cells modules and its uses		
5.	To describe working of the solar cell modules.		
6.	To design grid connected and standalone solar systems		
7.	To demonstrate knowledge of different solar thermal applications.		
Pre-Requisite:			
Sl. No.			
1.	Trigonometry, basic geometry, solid states & power electronics.		
Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours /Unit**	**Marks**

01	**Solar Radiation and Geometry** Solar radiation: measurements and prediction; Solar energy conversion techniques to heat and electricity; Spectrum of electromagnetic radiation, sun structure and characteristics, extraterrestrial radiation, solar constant, air mass, beam, diffused and total solar radiation, spectral distribution; Heat transfer processes applicable to solar energy, solar radiation, and its analysis; Solar geometry covering all parameter related to the position of the sun with respect to observer; Instruments for measurement of solar energy (Pyranometer/pyrheliometer/ sunshine recorder/lux meter), solar radiation on the collector; Depletion of solar radiation - absorption, scattering; beam radiation, diffuse and Global radiation; measurement of solar radiation; solar time - local apparent time (LAT) and equation of time(E).	**12**	**15**
02	**Solar PV Cells** P-N junction, Space charge region, Energy band Diagram, P-N junction potential, width of depletion region, carrier movements and current densities, generation of photovoltage, light generated current, I-V equation of solar cells, Solar cell characteristics, Figure of merits of solar cells, Losses in solar cells, Design specification of solar cells, Types of solar cells, Solar PV module and array, Shading impact: Bypass diode, blocking diode.	**12**	**15**
03	**Solar PV systems and its design** Maximum power point tracking (MPPT), Charge Controllers: Commonly used Set Points, Type of charge controllers (Shunt type, Series type and MPPT). Design methodology of PV systems: Design of PV powered DC fan without battery, Design of PV powered DC pump, Standalone PV system configurations (with different types of loads e.g. DC, with battery and DC, AC/DC, battery and AC/DC), Grid connected system without energy storage, Load characteristics, Effect of tracking. Applications of PV System: Direct coupled, Grid connected, Stand alone, Hybrid system, PV System Economics.	**12**	**15**
04	**Solar Thermal systems** Principles of heat and mass transfer, Thermodynamics, Fluid static and dynamics, Electricity generation, distribution and use, Basic of Solar Thermal Conversion, Technology of Selective Coating, Solar collectors, efficiency and testing of flat plate collectors, solar water heater, solar passive heating and cooling system, Solar industrial heating system,	**12**	**20**

	solar refrigeration and air conditioning, solar cookers, solar furnaces, solar green house, solar dryer, Solar distillation, Solar thermo mechanical systems.		
	Sub Total:	**40**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**

List of Books

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
C. S. Solanki	Solar Photovoltaics – Fundamentals, Technologies and Applications		PHI Learning, 2011
J N Roy and D N Bose	Photovoltaic Science and Technology		Cambridge University Press (2018)
Gilbert M Master	Renewable and Efficient Electric Power System		IEEE Press
S. A Kalogirou	Solar Energy Engineering: Process and Systems		Elsevier
S.P. Sukhatme and J. Nayak	Solar Energy: Principles of Thermal Collection and Storage, Third Edition		Tata McGraw Hill, 2008
S M Zee	Physics of Semiconductor Devices		

End Semester Examination Scheme. Maximum Marks-70. Time allotted-3hrs.

Group	**Unit**	**Objective Questions**	**Subjective Questions**

		(MCQ only with the correct answer)					
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

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Name of the Course:M.Tech in Renewable Energy **Subject: Renewable Energy II**			
Course Code: MRE 103		**Semester: 1**	
Duration: One Semester		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 2 hrs/wk		End Semester Exam: 70	
Tutorial: 1 hr/wk		Teacher's Assessment: 15	
Practical:		Internal Assessment: 15	
Credit: 3		Practical Sessional internal continuous evaluation:	
		Practical Sessional external examination:	
Aim:			
Sl. No.			
1.	This subject find utility in understanding concepts & gather knowledge about the different aspects, theories, applications and future prospects of bio energy, wind energy, tidal & wave energy.		
Objective:			
Sl. No.	The students will able		
1.	to identify different technologies for biomass conversion to energy, to generate bio-energy, bio gas and bio-fuelproduction		
2.	to describe the process used in harnessing and implementation of windenergy		
3.	to understand ocean thermal and tidal energytechnologies		
Pre-Requisite:			
Sl. No.			
1.	Bernoulli's equation, wave equation etc.		
Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours**	**Marks**

		/Unit	
01	World energy resources - Indian energy scenario - Environmental aspects of energy utilization; review of conventional energy resources - coal, gas, oil reserves and resources; Different form of non-conventional energy; Renewable energy resources and their importance – solar, wind, hydro, biomass, geothermal, and ocean energy, role of energy in economic development and socialtransformation	**12**	**10**
02	**Biomass:** Origin of biomass from different sources; Biomass resource assessment - Estimation of woody biomass, non woody biomass and wastes,ASTM standards. Bulk chemical properties - Moisture content, proximate and ultimate analyses, calorific value, and waste water analysis for solids; Anaerobic digestion, biogas production mechanism and technology, types of digesters, design of biogas plants, installation, operation and maintenance of biogas plants, biogas slurry utilization and management, biogas applications, cost benefit analysis of biogas for cooking, lighting, power generation applications, Feedstock for biogas, Microbial and biochemical aspects, operating parameters for biogas production. Kinetics and mechanism, Bio-hydrogen production: hydrolysis, fermentation. Biodiesel production, different types of raw materials, non-edible oil-seeds, Pyrolysis, mechanism of transesterification, fuel characteristics of biodiesel.	**12**	**20**
03	**Wind Energy:** **C**urrent status and future prospects; wind energy in India; power available in the wind; Anemometers and wind directions; environmental benefits and problems of wind energy; factors influencing the cost of energy generation - site specific parameters, World Meteorological Organization (WMO) specification, and machine parameters; wind energy conversion system (WECS): classification, characteristics, and applications; characteristics of wind rotor; wind turbine power and torque characteristics; types of rotors - horizontal and vertical axis wind turbine; Betz limit; Wind pumps - wind driven piston pumps, limitations, and performance analysis; atmospheric circulations, classification, factors influencing wind, wind shear, turbulence, wind speed monitoring, Wind pump basics: Its application and tip speed ratio calculation in withdrawing water; Dynamic wind pumps; Pulsating torque calculation.	**12**	**20**
04	**Ocean and Tidal :**	**12**	**15**

	Ocean energy resources, ocean energy routes; principles of ocean thermal energy conversion systems; principles of ocean wave energy conversion and tidal energy conversion; Ocean power generation: tidal energy estimation, components of tidal power plant, wave area of determining energy, mathematical analysis of wave energy. Wave energy conversion machine. Working principle –OTEC, Anderson closed cycle OTEC system, thermoelectric OTEC		
	Sub Total:	**48**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**

List of Books

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
Kothari	Renewable Energy Sources and Emerging Technologies		PHI, Eastern Economy Edition,2012.
R.K.Rajpoot	Non-Conventional Energy Sources and Utilization		S.ChandPublication, New Delhi.
K.C. Khandelwal and S.S. Mahdi	Biogas Technology– A Practical Handbook		Tata McGrawHill,1986.
Rai, G.D	Non-Conventional Energy Sources		KhannaPublishers, NewDelhi
N. K. Bansal and M. K. Kleema.	Renewable Sources of Energy and Conversion Systems		
J. Twidell & T. Weir	Renewable Energy Resources		Taylor and Francis; 2006 (2nd ed

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End Semester Examination Scheme. Maximum Marks-70. Time allotted-3hrs.

Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)		**Subjective Questions**			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

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Syllabus for M. Tech in Renewable Energy (In-house)
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Name of the Course:M.Tech in Renewable Energy **Subject: Nuclear Energy**	
Course Code: MRE 104	**Semester: 1**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs/wk	End Semester Exam: 70
Tutorial: 1 hr/wk	Teacher's Assessment: 15
Practical:	Internal Assessment: 15
Credit: 3	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Aim:	
Sl. No.	
1.	This subject find utility in understanding concepts & gather knowledge about the different aspects, theories, applications and future prospects of Nuclear energy.
Objective:	
Sl. No.	The students will able
1.	to gather knowledge of different fundamental concepts related to nuclear energy
2.	to know different components of nuclear powerplants
3.	to understand different safety measures and economics of nuclear energy
Pre-Requisite:	
Sl. No.	
1.	Bernoulli's equation, wave equation etc.

Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours /Unit**	**Marks**
01	Radioactivity, Radioactive decay, Isotopes, Nuclear reactions, fertile	**12**	**10**

	materials, Fission and fusion.		
02	Nuclear reactors, Definition and classifications, Essential components of nuclear reactor, Power of a nuclear reactor	**12**	**15**
03	Description of reactors, Pressurized water reactor, Boiling water reactor, Gas cooled reactor, Liquid metal cooled reactor, Breeder reactor, Reactor Design.	**12**	**20**
04	Chemical and biological effects of radiation, Nuclear waste disposal, Safety measures in Nuclear power plants, Nuclear power plant site selection, Economics of nuclear power plants, Nuclear Energy scenario in India	**12**	**20**
	Sub Total:	**48**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**

List of Books

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
R.K.Rajput	Non-Conventional Energy Sources and Utilization		S.ChandPublication
	Introduction to Nuclear Reactor Theory		Wesley,1966

End Semester Examination Scheme. **Maximum Marks-70.** **Time allotted-3hrs.**

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Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)		**Subjective Questions**			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

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Syllabus for M. Tech in Renewable Energy (In-house)
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Name of the Course:M.Tech in Renewable Energy **Subject: Power System Analysis**	
Course Code: MRE 105	**Semester: 1**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs/wk	End Semester Exam: 70
Tutorial: 1 hr/wk	Teacher's Assessment: 15
Practical:	Internal Assessment: 15
Credit: 2	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Aim:

Sl. No.	
1.	This subject find utility in understanding concepts & gather knowledge about the different aspects, theories, applications and future prospects of Power system related to renewable energy integration.

Objective:

Sl. No.	The students will able
1.	to understand the operation, strategies and different components of conventional thermal powerplants
2.	to understand economic operation, automatic control strategies of electricpower
3.	to gather knowledge about distributed generation and micro grids.

Pre-Requisite:

Sl. No.	
1.	Thermodynamic cycles, alternators, Power plant engineering

Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours /Unit**	**Marks**

01	Basic concepts of power plants, types of power plants, thermal power stations, Various components of thermal power stations, power plant cycles, fuel handling, combustion, waste disposal methodologies, economizers, turbo alternators, heat balance and efficiencies.	**12**	**15**
02	Economic operation of power generation: Generation cost curves; Economic operation of thermal system; Plant Scheduling; Transmission loss and penalty factor, Hydro-Thermal Scheduling; Concept of Reserve and Constraints; Unit Commitment, Tarrif.	**12**	**20**
03	State estimation and load forecasting, Concept of ALFC and AVR, Exciter and VAR control, Load frequency control.	**12**	**15**
04	Distributed generation, Hybrid power system, Integration of distributed generation to grid, Smart grid: Opportunities, challenges and benefits, Smart metering, Micro grid: AC and DC micro grids, Inter connection of micro grids.	**12**	**20**
	Sub Total:	**48**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**

List of Books

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
P.K.Nag	Power plant Engineering		Tata McGraw HillPublication
D.P.Kothari	Power System Engineering		TataMcGraw HillPublication
Ali Keyhani	Design of Smart Power Grid Renewable Energy Systems		Wiley
S.Chowdhury, S.P.Chowdhury and P. Crossley	Micro grids and Active Distribution Networks		IET,2009.
D.P.Kothari	Modern Power System		TataMcGraw HillPublication

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End Semester Examination Scheme. Maximum Marks-70. Time allotted-3hrs.

Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)		**Subjective Questions**			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

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Name of the Course:M.Tech in Renewable Energy **Subject: Safety & Disaster Management**	
Course Code: MRE 106	**Semester: 1**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs/wk	End Semester Exam: 70
Tutorial: 1 hr/wk	Teacher's Assessment: 15
Practical:	Internal Assessment: 15
Credit:2	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Aim:

Sl. No.	
1.	This subject find utility in understanding concepts & gather knowledge about the different aspects, theories of Safety & Disaster Management.

Objective:

Sl. No.	The students will able
1.	to demonstrate a critical understanding of key concepts in disaster risk reduction and humanitarianresponse
2.	Critically evaluate disaster risk reduction and humanitarian response policy and practice from multipleperspectives
3.	Critically understand the strengths and weaknesses of disaster management approach

Pre-Requisite:

Sl. No.	
1.	Thermodynamic cycles, alternators, Power plant engineering

Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours /Unit**	**Marks**

01	Evolution of modern safety concept, safety policy, safety organization, line and staff functions for safety, safety committee, budgeting for safety, Incident recall Technique (IRT), disaster control, Job Safety Analysis, safety survey, safety inspection, safety sampling, safety audit.	**12**	**15**
02	Concept of an accident, reportable and non-reportable accidents, unsafe act and condition, principles of accident prevention, Supervisory role, Role of safety committee, Accident causation models, Cost of accident, Overall accident investigation process, Response to accidents, India reporting requirement, Planning document, Planning matrix, Investigations kit, functions of investigator, four types of evidences, Records of accidents	**12**	**20**
03	Introduction on Disaster, Types of Disaster, Natural Disaster-prone areas in INDIA, Trends of major Disasters and their Impact on India, Introduction to Disaster Management, Disaster Management Act, 2005, National Disaster Management Structure, Organizations involved in DisasterManagement.	**12**	**20**
04	Overview on Hazard Analysis and Vulnerability Analysis, Disaster Preparedness, Disaster Prediction and Warning, Current tools and models used for Prediction and Early Warnings of Disaster, Disaster Response, Post-disaster Situation Awareness, Post-disaster Damage and Need Assessment, Rehabilitation, Reconstructions and Recovery, Disaster Mitigation.	**12**	**15**
	Sub Total:	**48**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**

List of Books

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
R. Nishith, Singh AK	Disaster Management in India: Perspectives, issues and strategies		New Royal bookCompany
Sahni, Pardeep	Disaster Mitigation Experiences And Reflections		Prentice Hall of India, NewDelhi

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End Semester Examination Scheme. Maximum Marks-70. Time allotted-3hrs.

Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)		**Subjective Questions**			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

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Name of the Course:M.Tech in Renewable Energy **Subject:Industrial Energy Analysis**			
Course Code: MRE 107 I		**Semester: 1**	
Duration: One Semester		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 2 hrs/wk		End Semester Exam: 70	
Tutorial: 1 hr/wk		Teacher's Assessment: 15	
Practical:		Internal Assessment: 15	
Credit:00		Practical Sessional internal continuous evaluation:	
		Practical Sessional external examination:	
Aim:			
Sl. No.			
1.	This subject find utility in understanding concepts & gather knowledge about the different aspects, theories of energy dealing in industrial sector		
Objective:			
Sl. No.	The students will able		
1.	to perform material balance calculations for a specific problem		
2.	to analyze a fluid flow system to select a pump/blower/compressor and estimate the efficiency of the operation		
3.	Given a small or medium sized industry, students will be able to suggest measures for improving energy efficiency		
Pre-Requisite:			
Sl. No.			
1.	Thermodynamics, Heat Transfer.		
Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours**	**Marks**

		/Unit	
01	Concepts of basis; mole fraction, mass fraction; Material balance without reaction – applications in renewable energy systems; Recycle and bypass calculations; Basics of energy balance – calculation of enthalpy in systems without reaction from mean/temperature-dependent heat capacity data, calculation of heat of reaction and adiabatic reaction temperature in reactive systems; Examples on combined material and energy balances in industrial processes	**12**	**15**
02	Heat transfer equipment fundamentals; methods for improving thermal and flow efficiency in heat exchangers – selection of suitable material of construction for tubes, optimizing shell and tube pressure drops; Energy efficiency analysis in boilers and furnaces; heat recovery in waste-heat boilers; heat recovery systems for gas turbines; efficiency analysis of wind turbine systems.	**12**	**20**
03	Energy efficiency of compression systems – basics of pumps, performance characteristics of centrifugal pumps, BEP in characteristic curve, analysis of series/parallel operation of centrifugal pumps, ways of avoiding cavitation; efficiency of fans and blowers; estimation of single stage and multistage compressor efficiency; estimation of piping losses; efficient design of piping networks by Hardy-Crossmethod.	**12**	**20**
04	Efficiency analysis of electrical heating systems – resistance, induction, microwave and radiant heating; characteristics of industrial electrical heating techniques; Lighting control systems for improving energy efficiency of lighting; Efficiency analysis of D.C. motors and Induction motors; control arrangements for D.C. motors and Induction motors. Analyzing energy efficiency for industrial SMEs	**12**	**15**
	Sub Total:	**48**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**

List of Books

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
B.K. Hodge	Analysis and Design of		PrenticeHall

	Energy Systems		
Card D Shields	Boilers – Types, Characteristics and Functions		McGrawHill
I.G.C. Dryden	The Efficient Use of Energy		ButterworthScientific
P. Thollander and J. Palm	Improving Energy Efficiency in Industrial Energy Systems		Springer

End Semester Examination Scheme. Maximum Marks-70. Time allotted-3hrs.

Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)		**Subjective Questions**			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

- Only multiple choice type question (MCQ) with one correct answer are to be set in the objective part.
- Specific instruction to the students to maintain the order in answering objective questions should be given on top of the question paper.

Maulana Abul Kalam Azad University of Technology, West Bengal
(Formerly West Bengal University of Technology)
Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course:M.Tech in Renewable Energy **Subject:Wastes to Energy**			
Course Code: MRE 107 II		**Semester: 1**	
Duration: One Semester		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 2 hrs/wk		End Semester Exam: 70	
Tutorial: 1 hr/wk		Teacher's Assessment: 15	
Practical:		Internal Assessment: 15	
Credit: 00		Practical Sessional internal continuous evaluation:	
		Practical Sessional external examination:	
Aim:			
Sl. No.			
1.	This subject find utility in understanding concepts & gather knowledge about the different aspects, theories of energy dealing different wastes generated during energy harvesting		
Objective:			
Sl. No.	The students will able		
2.	to perform material balance calculations for a specific problem		
3.	to analyze a fluid flow system to select a pump/blower/compressor and estimate the efficiency of the operation		
4.	Given a small or medium sized industry, students will be able to suggest measures for improving energy efficiency		
Pre-Requisite:			
Sl. No.			
1.	Thermodynamics, Heat Transfer.		
Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours**	**Marks**

		/Unit	
01	Introduction to Energy from Waste: Classification of waste as fuel – Agro based, Forest residue, Industrial waste – MSW, Fuels derived from waste and their properties -- Calorific value and composition, General ideas of Conversion Devices – Incinerators, Gasifiers, digesters.	**12**	**15**
02	Biomass Pyrolysis: Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, biochemical conversion - anaerobic digestion, yields and applications. - Types of biogas Plants –Alcohol production from biomass - Bio diesel production.	**12**	**20**
03	Biomass Gasification: Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation, Biomass Combustion: Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation of all the above biomasscombustors.	**12**	**20**
04	Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - Urban waste to energy conversion - Biomass energy program inIndia.	**12**	**15**
	Sub Total:	**48**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**

List of Books

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
Desai, Ashok V	Non Conventional Energy		Wiley Eastern Ltd., 1990
Khandelwal, K. C.	Biogas Technology - A		Tata McGraw Hill Publishing Co. Ltd.,

and Mahdi, S. S	Practical Hand Book		1983
C. Y. WereKo-Brobby and E. B. Hagan	Biomass Conversion and Technology		John Wiley & Sons, 1996.

End Semester Examination Scheme. Maximum Marks-70. Time allotted-3hrs.

Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)		**Subjective Questions**			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

- Only multiple choice type question (MCQ) with one correct answer are to be set in the objective part.
- Specific instruction to the students to maintain the order in answering objective questions should be given on top of the question paper.

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course:M.Tech in Renewable Energy **Subject: Energy Storage**	
Course Code: MRE 107 III	**Semester: 1**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs/wk	End Semester Exam: 70
Tutorial: 1 hr/wk	Teacher's Assessment: 15
Practical:	Internal Assessment: 15
Credit: 00	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Aim:

Sl. No.	
1.	This subject find utility in understanding concepts & gather knowledge about the different aspects, theories of energy dealing different wastes generated during energy harvesting

Objective:

Sl. No.	The students will able
1.	to store the renewable energy and their role in the world energy demand.
2.	To build basic knowledge of the energy storage material properties
3.	To utilize the technological methods related to efficient storage of renewable energy

Pre-Requisite:

Sl. No.	
1.	Thermodynamics, Heat Transfer.

Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours /Unit**	**Marks**
01	Introduction to energy storage for power systems: Need and role of energy storage systems in power system, General considerations, Energy and power balance in a storage unit, Mathematical model of	**12**	**15**

	storage, Econometric model of storage		
02	Overview on Energy storage technologies: Potential energy (Pumped hydro, Compressed Air,) - Kinetic energy (Mechanical- Flywheel) - Thermal energy without phase change passive (adobe) and active (water) - Thermal energy with phase change (ice, molten salts, steam) - Chemical energy (hydrogen, methane,) - Electrochemical energy (Batteries, Fuel cells) - Electrostatic energy (Super Capacitors), Electromagnetic energy (Super conducting Magnetic Energy Storage) - Different Types of Energy Storage Systems comparative analysis, Comparison of environmental impacts for differenttechnologies.	**12**	**20**
03	Energy storage Applications: Renewable energy generation- Solar energy, Wind Energy, pumped hydro energy, fuel cells, battery Storage- types, charging methodologies, SoC, SoH estimation techniques, Hydrogen production methods and storage. Smart Grid, Smart Microgrid, Smart House, Mobile storage system:Electric vehicles -G2V, V2G, Management and control hierarchy of storage systems - Aggregating EES systems and distributed generation	**12**	**20**
04	Virtual Power Plant Energy Management with storage systems, Battery SCADA, Hybrid Energy storage systems: configurations and applications Laboratory experiments: Simulation of energy storage systems and its management, smart park, Electric Vehicle charging facility, HESS in microgrid and smart grid, microbial fuel cell, hydrogen fuel cell and so on.	**12**	**15**
	Sub Total:	**48**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**

List of Books

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
A.G.Ter-Gazarian	Energy Storage for Power Systems", Second Edition, The Institution of Engineering and Technology		(IET) Publication,UK

Francisco Díaz-González, Andreas Sumper, Oriol Gomis-Bellmunt	Energy Storage in Power Systems		Wiley Publication
R. Pendse	Energy Storage Science and Technology		SBS Publishers & Distributors Pvt. Ltd., New Delhi

End Semester Examination Scheme. Maximum Marks-70. Time allotted-3hrs.

Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)		**Subjective Questions**			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

- Only multiple choice type question (MCQ) with one correct answer are to be set in the objective part.
- Specific instruction to the students to maintain the order in answering objective questions should be given on top of the question paper.

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course:M.Tech in Renewable Energy **Subject: Energy Technology Laboratory**	
Course Code: MRE 191	**Semester: 1**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory:	End Semester Exam:
Tutorial:	Teacher's Assessment:
Practical: 4hrs/wk	Internal Assessment:
Credit: 02	Practical Sessional internal continuous evaluation: 50
	Practical Sessional external examination: 50

Practical:

Skills to be developed:

Intellectual skills:

1. Identification of instruments.
2. Selection of proper instruments.

Motor Skills:

1. Accurate measurement.
2. Instrument handling.
3.
4.
5.

List of Practical:

1. Determination of Flash point of oil by ABELapparatus.
2. Determination of flash point and fire point of a fuel oil by Pesusky-Martins apparatus.
3. Determination of moisture content of fuel oil by Dean Sterk apparatus.
4. Atmospheric distillation of petroleum product using ASTMapparatus.
5. Determination of kinematic viscosity of oil by Redwoodviscometer.
6. Determination of calorific value of coal by bombcalorimeter.
7. Determination of calorific value of gaseous fuel Junker'scalorimeter.
8. Proximate analysis ofcoal.
9. Orsat analysis of fuel and flue gases.
10. Determination of carbon residue of fuel oil by Conradsonapparatus.
11. Determination of annealing point of liquidfuel.

12. Determination of Reid vapours pressure of petroleum product by Reidapparatus.

Assignments:

List of equipment/apparatus for laboratory experiments:

Sl. No.	
1.	ABELapparatus
2.	Pensky-Martins apparatus
3.	Dean Sterk apparatus
4.	ASTMapparatus
5.	Redwoodviscometer
6.	Bombcalorimeter
7.	Bombcalorimeter
8.	Orsat apparatus
9.	Conradson apparatus
10.	Reid vapour pressure apparatus

E X A M I N A T I O N S C H E M E (SESSIONAL)

1. Continuous Internal Assessment of 50 marks is to be carried out by the teachers throughout the first Semester. Distribution of marks: Performance of Job – 30, Notebook – 20.

2. External Assessment of 50 marks shall be held at the end of the Third Semester on the entire syllabus. One Experiment per student from any one of the above is to be performed. Experiment is to be allotted by lottery system. Distribution of marks: On spot job – 30, Viva-voce – 20.

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course:M.Tech in Renewable Energy

Subject: Power Laboratory

Course Code: MRE 192	**Semester: 1**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory:	End Semester Exam:
Tutorial:	Teacher's Assessment:
Practical: 4 hrs/wk	Internal Assessment:
Credit: 02	Practical Sessional internal continuous evaluation: 50
	Practical Sessional external examination: 50

Practical:

Skills to be developed:

Intellectual skills:

1. Identification of instruments.
2. Selection of proper instruments.
3.

Motor Skills:

1. 1. Accurate measurement.
2. Instrument handling.

List of Practical:

1. Determination of the generalized ABCD Constant of a transmissionline.
2. OC and SC test and Polarity test of a single phasetransformer.
3. Different methods of starting of a 3 phase Induction Motor & theircomparison.
4. Speed control of 3 phase squirrel cage induction motor by different methods & their comparison.
5. Study of the characteristics of a separately excited DCgenerator.
6. Study of the characteristics of a DCmotor

Assignments:

List of equipment/apparatus for laboratory experiments:	
Sl. No.	
1.	**Voltmeter**
2.	**Ammeter**
2.	**Watt meter**
3.	**Tacho meter**
4.	**Experiment set ups**

E X A M I N A T I O N S C H E M E (SESSIONAL)

1. Continuous Internal Assessment of 50 marks is to be carried out by the teachers throughout the first Semester. Distribution of marks: Performance of Job – 30, Notebook – 20.

2. External Assessment of 50 marks shall be held at the end of the Third Semester on the entire syllabus. One Experiment per student from any one of the above is to be performed. Experiment is to be allotted by lottery system. Distribution of marks: On spot job – 30, Viva-voce – 20.

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Curriculum Structure

MAKAUT												
TEACHING AND EXAMINATION SCHEME FOR M.TECH COURSE												
COURSE NAME: RENEWABLE ENERGY												
COURSE CODE : MRE												
DURATION OF COURSE : 2 YEARS												
SEMESTER:SECOND SEMESTER						SCHEME :						
Sr. No.	SUBJECT Code	SUBJECT	PERIODS			EVALUATION SCHEME						Credits
THEORY			L	T	P	SESSIONSAL EXAM			ESE	PR (I NT.)	PR (EX T.)	
						TA	CT	Total				
1	MRE201	Renewable Energy III	02	01	--	15	15	30	70	--	--	3
2	MRE202	Transport Processes and Thermodynamics	02	01	--	15	15	30	70	--	--	3
3	MRE203	Materials and devices for energy conversion and storage	02	01	--	15	15	30	70	--	--	3
4	MRE204	Mathematical methods and modelling	02	01	--	15	15	30	70			3
5	MRE205I/II/ III/IV	IOT and Smart sensors/Artificial Intelligence/ Distributed Generation and Smart Grids/Social awareness program in green environment	02	01	--	15	15	30	70	--	--	0
6	MRE291	Renewable energy lab I	--	--	04	--	--	--	--	50	50	2
7	MRE292	Renewable energy lab II	--	--	04	--	--	---	--	50	50	2
8	MRE281	Seminar	--	--	02							2

STUDENT CONTACT HOURS PER WEEK: 30
THEORY AND PRACTICAL PERIODS OF 60 MINUTES EACH

ABBREVIATIONS: CT- Class Test, TA - Teachers Assessment, L - Lecture, T - Tutorial, PR (INT.) – Practical (Internal) PR(EXT.)- Practical(External), ESE - End Semester Exam.

TA: Attendance & surprise quizzes = 6 marks. Assignment & Group Discussion = 4 marks.

Minimum passing for sessional marks is 40%, and for theory subject 40%.

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Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course: M. Tech in Renewable Energy **Subject: Renewable Energy III**			
Course Code: MRE 201		**Semester: 2**	
Duration: One Semester		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 2 hrs/wk		End Semester Exam: 70	
Tutorial: 1 hr/wk		Teacher's Assessment: 15	
Practical:		Internal Assessment: 15	
Credit: 3		Practical Sessional internal continuous evaluation:	
		Practical Sessional external examination:	
Aim:			
Sl. No.			
1.	This subject find utility in understanding concepts & gather knowledge about the different aspects, theories of hydel energy, geo-thermal energy, fuel & hydrogen cells		
Objective:			
Sl. No.	The students will able		
1.	to understand Geo thermal energytechnologies		
2.	categorize hydraulic turbines in generatinghydropower		
3.	To various fuel celltechnologies& their application		
Pre-Requisite:			
Sl. No.			
1.	Thermodynamics, Heat Transfer, turbines & alternators.		
Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours /Unit**	**Marks**
01	**Geo thermal energy:**	**12**	**15**

	Availability of geothermal energy-size and distribution; recovery of geothermal energy, various types of systems to use geothermal energy; Power generation using geothermal heat, Sustainability of geothermal source, Geothermal heat pump and geothermal energy scenario in India		
02	**Hydro power:** Classification of hydropower plants, small hydropower systems: overview of micro, mini, and small hydro systems; status of hydropower worldwide; advantages and disadvantages of Hydropower; Methods for determining head and flow, Types and Operational Aspects Classification of Hydraulic Turbines, Operational Aspects of Turbines Efficiency and selection of turbines; Weirs, Dam and Spillway, Surge Chambers, Penstock,Tailrace.	**12**	**20**
03	**Fuel cells:** History – principle - working - thermodynamics and kinetics of fuel cell process – performance evaluation of fuel cell – comparison on battery Vs fuel cell, Types of fuel cells , relative merits and demerits, Polarization curve- Activation loss, Ohmic loss, and Mass transport loss. Applications of fuel cells: Fuel cell usage for domestic power systems, large scale power generation, Automobile, Space, economic and environmental analysis on usage of hydrogen and fuel cell	**12**	**20**
04	**Hydrogen cell:** Introduction of hydrogen energy systems: Properties of hydrogen as fuel, Hydrogen pathways introduction-current uses, general introduction to infrastructure requirement for hydrogen production, storage, dispensing and utilization, and hydrogen production plants. Hydrogen storage: Physical and chemical properties, general storage methods, compressed storage-composite cylinders, glass micro sphere storage, zeolites, metal hydride storage, chemical hydride storage and cryogenic storage, carbon based materials for hydrogen storage.	**12**	**15**
	Sub Total:	**48**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**
List of Books			

Maulana Abul Kalam Azad University of Technology, West Bengal
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(Applicable from the academic session 2019-2020)

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
Basu.S	Recent Trends in Fuel Cell Science and Technology		
H. Wanger, J. Mathur	Introduction to Hydro energy Systems: Basics, Technology and Operation		Springer,2011
N. K. Bansal and M. K. Kleeman.	Renewable Sources of Energy and Conversion Systems		
H. Wanger, J. Mathur	Introduction to Hydro energy Systems: Basics, Technology and Operation		Springer,2011
R.K.Rajpoot	Non-Conventional Energy Sources and Utilization		S.ChandPublication, New Delhi.

End Semester Examination Scheme. **Maximum Marks-70.** **Time allotted-3hrs.**

Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)		**Subjective Questions**			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

- Only multiple choice type question (MCQ) with one correct answer are to be set in the objective part.
- Specific instruction to the students to maintain the order in answering objective questions should be given on top of the question paper.

Name of the Course: M. Tech in Renewable Energy **Subject: Transport Processes & Thermodynamics**	
Course Code: MRE 202	**Semester: 2**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs/wk	End Semester Exam: 70
Tutorial: 1 hr/wk	Teacher's Assessment: 15
Practical:	Internal Assessment: 15
Credit: 3	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Aim:

Sl. No.	
1.	This subject find utility in understanding concepts & gather knowledge about the different transport processes & thermodynamics.

Objective:

Sl. No.	The students will able
1.	to understand mass & heat transfer technologies
2.	To understand concepts of thermodynamics

Pre-Requisite:

Sl. No.	
1.	Heat & Mass

Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours /Unit**	**Marks**

01	**Fluid Mechanics:** Transport Theorem, introduction to momentum transfer, concept of continuum, viscosity and mechanisms of momentum transport, momentum flux, Newton's law of viscosity, shear stresses during laminar flow, Non-Newtonian fluids,Bingham model, Eyring model, Reiner-Philippoff model, convective momentum transport, shell momentum balances and velocity profiles in laminar flow between flat plates, rectangular channels, circular tubes and pipes, annulus, flow around a sphere, continuity equation for both Newtonian and non- Newtonian fluids, flow of falling films with constant and variable viscosity, equations of continuity in Eulerian and Lagrangian form, equations of motion-Euler and Navier Stokes, control volume approach, applications of these equations in steady and unsteady state problems, unsteady state laminar flow of Newtonian fluids in various geometries, concept of stream function and velocity potential, boundary layer theory , velocity distributions in turbulent flow through ducts and circular tubes, momentum flux, application of Prandtl mixing length to turbulent flow, concept of Reynold's stresses, eddy viscosity, Reynold's averaged Navier Stokes equations, interphase transport, and concept of friction factor during flow through tubes, packed bedsetc.	**12**	**20**
02	**Heat Transfer:** Modes of heat transfer, heat flux and Fourier's law of heat conduction, concept of thermal conductivity and diffusivity, shell energy balances and boundary conditions: heat sources: electrical, nuclear, viscous, chemical. Steady state heat conduction without heat generation for systems of different geometries e.g. composite walls, cylinders, spheres, having constant and variable thermal conductivities, conduction with generation: Poisson equation, conduction with temperature dependent generation, unsteady state heat conduction in finite and semi-infinite. Convection and Newton's law of cooling, heat transfer coefficient, different boundary conditions in the energy equations, cooling of a solid forced and free convection, transpiration cooling, viscous flow and development of boundary layer, heat transfer in laminar flow through a tube, natural convection on a vertical plate , turbulent heat transfer in channels.	**12**	**15**
03	**Mass Transfer:** Analogies among momentum, heat and mass transfer, dimensional analysis, derivation of important dimensionless groups and	**12**	**15**

	significance of dimensionless groups in momentum, heat and mass transport, simultaneous mass, heat, momentum transfer and their industrial applications, e.g. applications of momentum heat and mass transport concepts for detailed design and analysis of cooling towers, distillation columns, absorbers, reactors, dryers, application of energy balance in solar cells, fuel cells, biogas generation etc, case studies of several plants e.g. thermal power plants, refineries, petrochemical industries, pharmaceutical industries, textile industries, desalination plants, effluent treatment unit		
04	**Thermodynamics:** Concept of Macroscopic approach to thermodynamics, path and point functions. Intensive and extensive property, thermodynamic system and their types.Thermodynamic Equilibrium State.Quasi-static, reversible and irreversible processes, Displacement work and other modes of work.p-v diagram. Application of First law of thermodynamics, Steady flow energy equation applied to nozzle, diffuser, boiler, turbine, compressor, pump, heat exchanger, Heat Reservoir, source and sink. Heat Engine, Refrigerator, Heat pump, Equivalence of second law statements and its corollaries. Concept of entropy, Applications of 2nd Law of thermodynamics, Exergy destruction in heat transfer process, exergy of finite heat capacity body, exergy of closed and steady flow system; 1st and 2nd law Efficiency, Thermochemistry: Enthalpy, Heat of reaction at constant pressure and volume, Hess's Law of constant heat summation, Vapor Power cycles: Carnot vapor cycle, Rankine cycle, comparison of Carnot and Rankine cycle, Gas Power cycles: Otto and Diesel cycle, Dual cycle, Comparison of Otto, Diesel and Dual cycles, air standard efficiency, mean effective pressure, brake thermal efficiency, relative efficiency, Brayton cycle.	**12**	**20**
	Sub Total:	**48**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**

List of Books

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**

B.R. Bird, W. E. Stewart, and E. N. Lightfoot	Transport Phenomena, 2nd edtn.		John Wiley &Sons
W.M. Deen	Analysis of transport phenomena, 2nd ed		Oxford UniversityPress
P.K. Nag	Engineering Thermodynamics		McGraw-HillEducation
by Borgnakke & Sonntag	Fundamentals of Thermodynamics		Wiley India (P)Ltd

End Semester Examination Scheme. Maximum Marks-70. Time allotted-3hrs.

Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)		**Subjective Questions**			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

- Only multiple choice type question (MCQ) with one correct answer are to be set in the objective part.
- Specific instruction to the students to maintain the order in answering objective questions should be given on top of the question paper.

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Name of the Course:M.Tech in Renewable Energy **Subject:Materials and Devices for Energy Conversion and Storage**	
Course Code: MRE 203	**Semester: 2**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs/wk	End Semester Exam: 70
Tutorial: 1 hr/wk	Teacher's Assessment: 15
Practical:	Internal Assessment: 15
Credit: 3	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Aim:

Sl. No.	
1.	This subject find utility in understanding concepts & gather knowledge about the different aspects, theories of energy conversion & storage materials,

Objective:

Sl. No.	The students will able
1.	To get familiarized with the properties of different materials- metals and nonmetals
2.	Ability to design photovoltaic material and its electronic properties for the solar energyapplication
3.	understand the role of selection for the wind turbine material and it requiredproperties

Pre-Requisite:

Sl. No.	
1.	Solar cells, wind turbine,battery, capacitors

Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours /Unit**	**Marks**
01	Nanomaterial for renewable energy: Classification of nanomaterials – zero-dimensional, one- dimensional, two-dimensional, three-	**12**	**15**

	dimensional; Synthesis of nanomaterials: Bottom up and top down approaches, colloidal method, chemical vapor deposition (CVD) methods, wet chemical methods, sol-gel synthesis, and mechanical exfoliation methods, physical vapor deposition (PVD), sputtering, plasma enhanced CVD (PECVD), hot wire CVD (HWCVD), Nano-structured materials with applications - quantum dots, nano-tubes, nano- wires, nano- crystals.		
02	Materials for photovoltaic conversions, Si and non-Si materials, crystalline, semi crystalline, polycrystalline and amorphous materials; Nano, micro, and poly-crystalline Si for solar cells, mono-micro silicon composite structure; Technology for Si extraction, purification; Method of doping and junction fabrication; Cell fabrication and metallization techniques; Networking the PV cell; P-N junction, sources of losses and prevention, Concepts on high efficiency solar cells, tandem and multi-junction solar cells, photo-voltaic materials and photo-voltaic modules and their applications; Solar PV concentrator cells and systems, III- V, II-IV compound materials thin film solar cells.	**12**	**20**
03	Materials for wind turbines- blades, nacelles, and tower; Important properties of the blade, Metal and polymer-composite material for blade and tower; Rotor blade – properties and application; Erecting of the tower material, Support materials for wind tower, Corrosion issues; importance of nacelles in wind turbine and its component. Mechanical properties: flexural strength, bending moment, strength of material- yield strength, ultimate strength, Young's modulus, Poisson's ratio, and fatigue; Universal testing machine (UTM); shear webs for wind turbine blades.	**12**	**20**
04	Electronic and atomic structures of solar cell material; Atomic bonding in solids, crystal structure, microstructure, solidification, alloys; Description of optical and thermal materials for solar cell application. Material characterization: Scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD), Single crystal X-Ray diffraction, Ultraviolet visible spectroscopy, Raman spectroscopy, atomic force microscopy (AFM), and X-ray photoelectron spectroscopy (XPS); Pulse layer deposition (PLD), PV cell diode properties, PV cell series resistance, PV cell shunt resistance.	**12**	**15**
	Sub Total:	**48**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**

	Total:		**100**

List of Books

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
A. da Rosa	Fundamentals of Renewable Energy Processes, 3rd ed		
Martin A.Green	Solar Cells: Operating principles, technology and system applications		Prentice- Hall Inc, Englewood Cliffs, NJ, USA,1981
C.N.R. Rao, A. Muller and A.K. Cheetham	Nanomaterials Chemistry - Recent Developments and New Directions		WileyVCH
H.J. Moller	Semiconductor for solar cells,		Artech House Inc, MA, USA,1993
C. Barbec, V.Dyakonov, J.Parisi, N.S.Saricittci	Organic photovoltaics: Concepts and realization		Springer-Verlag2003
R.P.L. Nijssen, P. Brøndsted	Advances in wind turbine blade design and materials		Elsevier,2013

End Semester Examination Scheme. **Maximum Marks-70.** **Time allotted-3hrs.**

Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)		**Subjective Questions**			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks

A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

- Only multiple choice type question (MCQ) with one correct answer are to be set in the objective part.
- Specific instruction to the students to maintain the order in answering objective questions should be given on top of the question paper.

Name of the Course:M.Tech in Renewable Energy **Subject:Mathematical Methods and Modelling**	
Course Code: MRE 204	**Semester: 2**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs/wk	End Semester Exam: 70
Tutorial: 1 hr/wk	Teacher's Assessment: 15
Practical:	Internal Assessment: 15
Credit: 3	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Aim:	
Sl. No.	
2.	This subject find utility in understanding concepts & gather knowledge about the different aspects, theories of energy conversion & storage materials,

Objective:	
Sl. No.	The students will able
4.	To learn and practice different mathematical methods for engineering applications
5.	to gather knowledge about different statistical models and its applications

Pre-Requisite:	
Sl. No.	

1.	Calculus, Algebra

Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours /Unit**	**Marks**
01	Fourier transform, Laplace transform, Solution of differential equations by Laplace and Fourier transform methods, Applications of Laplace and Fourier transforms to Boundary value problems arising in Engineering Sciences, Solutions of Laplace, Wave and Heat Conduction Equations, Basic ideas of Discrete Fourier transform (DFT) and Finite Fourier transform (FFT), Z-transform, and Applications, Basic ideas of Discrete Fourier transform (DFT) and Finite Fourier transform (FFT), Z-transform, and Applications	**12**	**15**
02	Partial differential equations: first and second order equations time dependent boundary conditions Green function. Superposition principle: moving boundary problems: approximate methods of solution. Numerical methods for solutions of differential equations, linear and non-linear, analysis of convergence, error and stability.	**12**	**20**
03	Statistical Models - Concepts – Discrete Distribution- Continuous Distribution – Poisson Process- Empirical Distributions- Queueing Models – Characteristics- Notation Queueing Systems – Markovian Models- Properties of random numbers- Generation of Pseudo Random numbers- Techniques for generating random numbers- Testing random number generators, Generating Random-Variates- Inverse Transform technique Acceptance- Rejection technique – Composition & Convolution Method.	**12**	**20**
04	Introduction – Simulation Terminologies- Application areas – Model Classification Types of Simulation- Steps in a Simulation study- Concepts in Discrete Event Simulation Example, Input Modeling - Data collection - Assessing sample independence – Hypothesizing distribution family with data - Parameter Estimation - Goodness-of-fit tests – Selecting input models in absence of data- Output analysis for a Single system – Terminating Simulations – Steady state simulations. ANOVA (one way & two way).usage of MATLAB .Econometric techniques used for energy analysis with case studies.Input-output analysis, Energy multiplier and implication of energy multiplier for analysis of regional and national energy policy.	**12**	**15**
	Sub Total:	**48**	**70**

	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**

List of Books

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
Jerry Banks and John Carson	Discrete Event System Simulation		PHI, 2005
Geoffrey Gordon	System Simulation		PHI, 2006
Erwin Kreyszig	Advanced Engineering Mathematics, 10ed, ISV		Wiley

End Semester Examination Scheme. Maximum Marks-70. Time allotted-3hrs.

Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)		**Subjective Questions**			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

- Only multiple choice type question (MCQ) with one correct answer are to be set in the objective part.
- Specific instruction to the students to maintain the order in answering objective questions should be given on top of the question paper.

Maulana Abul Kalam Azad University of Technology, West Bengal
(Formerly West Bengal University of Technology)
Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course:M.Tech in Renewable Energy **Subject: IOT and Smart Sensors**	
Course Code: MRE 205 I (Elective)	**Semester: 2**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs/wk	End Semester Exam: 70
Tutorial: 1 hr/wk	Teacher's Assessment: 15
Practical:	Internal Assessment: 15
Credit:00	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Aim:

Sl. No.	
1.	This subject find utility in understanding concepts & gather knowledge about the different aspects and application of IOT & sensors.

Objective:

Sl. No.	The students will able
1.	to gather knowledge on new internet based technology for modern society.
2.	to know about different smart sensors useful for renewable energy application.

Pre-Requisite:

Sl. No.	
1.	Basics of industrial application and sensors

Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours /Unit**	**Marks**
01	The Internet of Things Today, Time for Convergence, Towards the IoT Universe, Internet of Things Vision, IoT Strategic Research and Innovation Directions, IoT Applications, Future Internet Technologies, Infrastructure, Networks and Communication, Processes, Data Management, Security, Privacy & Trust, Device Level Energy Issues,	**12**	**15**

	IoT Related Standardization, Recommendations on Research Topics.		
02	IoT Applications for Value Creations Introduction, IoT applications for industry: Future Factory Concepts, Brownfield IoT, Smart Objects, Smart Applications, Four Aspects in your Business to Master IoT, Value Creation from Big Data and Serialization, IoT for Retailing Industry, IoT For Oil and Gas Industry, Opinions on IoT Application and Value for Industry, Home Management, e-Health	**12**	**20**
03	Sensors: Working Principles: Different types; Selection of Sensors for Practical Applications Introduction of Different Types of Sensors such as Capacitive, Resistive, Surface Acoustic Wave for Temperature, Pressure, Humidity, Toxic Gas etc , Important Characteristics of Sensors: Determination of the Characteristics Fractional order element: Constant Phase Impedance for sensing applications such as humidity, water quality, milk quality Impedance Spectroscopy: Equivalent circuit of Sensors and Modelling of Sensors Importance and Adoption of Smart Sensors	**12**	**20**
04	Architecture of Smart Sensors: Important components, their features Fabrication of Sensor and Smart Sensor: Electrode fabrication: Screen printing, Photolithography, Electroplating Sensing film deposition: Physical and chemical Vapor, Anodization. Interface Electronic Circuit for Smart Sensors and Challenges for Interfacing the Smart Sensor, Usefulness of Silicon Technology in Smart Sensor And Future scope of research in smart sensor Recent trends in smart sensor for day to day life, evolving sensors and their architecture	**12**	**15**
	Sub Total:	**48**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**

List of Books

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
Yasuura, H., Kyung, C.-M., Liu, Y., Lin, Y.-L	Smart Sensors at the IoT Frontier		Springer InternationalPublishing

Vijay Madisetti and Arshdeep Bahga	Internet of Things (A Hands-on-Approach)		VPT,2014.
Cuno Pfister	Getting Started with the Internet of Things		OReilly Media,2011

End Semester Examination Scheme. Maximum Marks-70. Time allotted-3hrs.

Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)		**Subjective Questions**			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

- Only multiple choice type question (MCQ) with one correct answer are to be set in the objective part.
- Specific instruction to the students to maintain the order in answering objective questions should be given on top of the question paper.

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course:M.Tech in Renewable Energy **Subject:Artificial Intelligence**	
Course Code: MRE 205 II (Elective)	**Semester: 2**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs/wk	End Semester Exam: 70
Tutorial: 1 hr/wk	Teacher's Assessment: 15
Practical:	Internal Assessment: 15
Credit: 00	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Aim:	
Sl. No.	
1.	This subject find utility in understanding concepts & gather knowledge about the different aspects and application of artificial intelligence.
Objective:	
Sl. No.	The students will able
1.	to understand different methods and techniques of Artificial Intelligence
2.	to know different application areas of ArtificialIntelligence
Pre-Requisite:	
Sl. No.	
1.	Basics of industrial application

Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours /Unit**	**Marks**
01	hat is AI (Artificial Intelligence)? : The AI Problems, The Underlying Assumption, What are AI Techniques, The Level Of The Model, Criteria For Success, Some General References, One Final WordProblems, State Space Search & Heuristic Search Techniques: Defining The Problems As A State Space Search, Production Systems, Production	**12**	**15**

	Characteristics, Production System Characteristics, And Issues In The Design Of Search Programs, Additional Problems. GenerateAnd-Test, Hill Climbing, Best-First Search, Problem Reduction, Constraint Satisfaction, Means EndsAnalysis		
02	Knowledge Representation Issues: Representations And Mappings, Approaches To Knowledge Representation. Using Predicate Logic: Representation Simple Facts In Logic, Representing Instance And Isa Relationships, Computable Functions And Predicates, Resolution. Representing Knowledge Using Rules: Procedural Versus Declarative Knowledge, Logic Programming, Forward Versus Backward Reasoning.	**12**	**20**
03	Symbolic Reasoning Under Uncertainty: Introduction To No monotonic Reasoning, Logics For Non-monotonic Reasoning. Statistical Reasoning: Probability And Bays' Theorem, Certainty Model Curriculum of Engineering & Technology PG Courses [Volume -II] 289 Factors And Rule-Base Systems, Bayesian Networks, Dempster Shafer Theory Fuzzy Logic. Weak Slot-and-Filler Structures: Semantic Nets, Frames. Strong Slot-and-Filler Structures: Conceptual Dependency, Scripts, CYC	**12**	**20**
04	Game Playing: Overview, And Example Domain: Overview, Mini-Max, Alpha-Beta Cut-off, Refinements, Iterative deepening, The Blocks World, Components Of A Planning System, Goal Stack Planning, Nonlinear Planning Using Constraint Posting, Hierarchical Planning, Reactive Systems, Other Planning Techniques. Understanding: What is understanding? What makes it hard? As constraint satisfaction Natural Language Processing: Introduction, Syntactic Processing, Semantic Analysis, Semantic Analysis, Discourse And Pragmatic Processing, Spell Checking Connectionist Models: Introduction: Hopfield Network, Learning In Neural Network, Application Of Neural Networks, Recurrent Networks, Distributed Representations, Connectionist AI And Symbolic AI.	**12**	**15**
	Sub Total:	**48**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**

List of Books

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
Elaine Rich and Kevin Knight	Artificial Intelligence		Tata Mcgraw- Hill, 2005
Stuart Russel and Peter Norvig	Artificial Intelligence: A Modern Approach		Prentice Hall,2009.

End Semester Examination Scheme. Maximum Marks-70. Time allotted-3hrs.

Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)		**Subjective Questions**			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

- Only multiple choice type question (MCQ) with one correct answer are to be set in the objective part.
- Specific instruction to the students to maintain the order in answering objective questions should be given on top of the question paper.

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course:M.Tech in Renewable Energy **Subject:Distributed Generation and Smart Grids**	
Course Code: MRE 205 III (Elective)	**Semester: 2**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs/wk	End Semester Exam: 70
Tutorial: 1 hr/wk	Teacher's Assessment: 15
Practical:	Internal Assessment: 15
Credit: 00	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Aim:

Sl. No.	
1.	This subject find utility in understanding concepts & gather knowledge about the different aspects and application of distributed generation & smart grids.

Objective:

Sl. No.	The students will able
1.	to know about different types of distribute generations
2.	To gather knowledge about strategy, protectionschemes, features of micro grid and smart grid

Pre-Requisite:

Sl. No.	
1.	Power system, Energy resources

Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours /Unit**	**Marks**
01	Need for Distributed generation, Renewable sources in distributed generation, Current scenario in Distributed Generation, Planning of DGs, Sitting and sizing of DGs optimal placement of DG sources in distribution systems, Grid integration of DGs Different types of	**12**	**15**

	interfaces, Inverter based DGs and rotating machine based interfaces, Aggregation of multiple DGunits		
02	Technical impacts of DGs, Transmission systems Distribution systems De-regulation Impact of DGs upon protective relaying, Impact of DGs upon transient and dynamic stability of existing, distribution systems, Steady-state and Dynamic analysis, Economic and control aspects of DGs Market facts, issues and challenges Limitations of DGs, Voltage control techniques, Reactive power control, Harmonics Power quality issues, Reliability of DG based systems.	**12**	**20**
03	Introduction to micro-grids, Types of micro-grids: autonomous and non-autonomous grids Sizing of micro-grids, Modelling & analysis of Micro-grids with multiple DGs, Micro-grids with power electronic interfacing units, Transients in micro-grids, Protection of micro-grids, Case studies, Advanced topics	**12**	**20**
04	Introduction to Smart Grid, Evolution of Electric Grid, Model Curriculum of Engineering & Technology PG Courses, Concept of Smart Grid, Definitions, Need of Smart Grid, Concept of Robust &Self Healing Grid, Present development & International policies in Smart Grid, Introduction to Smart Meters,Real Time Prizing, Smart Appliances, Automatic Meter Reading(AMR), Outage Management System(OMS), Plug in Hybrid Electric Vehicles(PHEV), Vehicle to Grid, Smart Sensors, Power Quality & EMC in Smart Grid, Power Quality issues of Grid connected Renewable Energy Sources, Power Quality Conditioners for Smart Grid, Web based Power Quality monitoring, Advanced Metering Infrastructure (AMI), Home Area Network (HAN), Neighborhood Area Network(NAN).	**12**	**15**
	Sub Total:	**48**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**

List of Books

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
Ali Keyhani	Design of smart power grid renewable energy systems		WileyIEEE,2011

Clark W. Gellings	The Smart Grid: Enabling Energy Efficiency and Demand Response		CRC Press ,2009
JanakaEkanayake, Nick Jenkins, Kithsiri Liyanage	Smart Grid: Technology and Applications		Wiley2012

End Semester Examination Scheme. Maximum Marks-70. Time allotted-3hrs.

Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)		**Subjective Questions**			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

- Only multiple choice type question (MCQ) with one correct answer are to be set in the objective part.
- Specific instruction to the students to maintain the order in answering objective questions should be given on top of the question paper.

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course:M.Tech in Renewable Energy **Subject: Social awareness program on green environment**	
Course Code: MRE 205 IV(Elective)	**Semester: 2**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory:	End Semester Exam:
Tutorial:	Teacher's Assessment:
Practical:2 hrs/wk	Internal Assessment:
Credit: 00	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Aim:	
Sl. No.	
1.	To carryout awareness program in educational institutions, different local bodies on the aspect of green and clean energy resources, efficient combustion of fuels, global warming, atmospheric pollution, water pollution, soil pollution, indiscriminate use of pesticides and chemical fertilizers, food adulteration.Submission of feed -back report

Objective:	
Sl. No.	The students will able
3.	to know about collaboration with social bodies
4.	To gather knowledge about social awareness

Pre-Requisite:	
Sl. No.	
1.	Environmental pollution

Maulana Abul Kalam Azad University of Technology, West Bengal
(Formerly West Bengal University of Technology)
Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course: M.Tech in Renewable Energy

Subject: Renewable Energy Lab I

Course Code: MRE 291	**Semester: 2**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory:	End Semester Exam:
Tutorial:	Teacher's Assessment:
Practical: 4 hrs/wk	Internal Assessment:
Credit: 02	Practical Sessional internal continuous evaluation: 50
	Practical Sessional external examination: 50

Practical:

Skills to be developed:

Intellectual skills:

1. Measurement of solar parameters.
2. Process of different measurement schemes.

Motor Skills:

1. Proper handling of solar instruments.
2. Data collection schemes

List of Practical:

1. Study of solarradiation

2. Performance evaluation of solarcooker.

3. Performance evaluation of solarpanel.

4. Performance of PV panel in series and parallel.

5. Charging characteristics of battery with PVpanel.

6. Effect of tilt angle on PVpanel.

7. Effect of shadow on PVpanel.

8. Effect of temperature on PVpanel.

9. Performance evaluation of solarpump.

10. Performance evaluation of solarcollectors.

Assignments:

List of equipment/apparatus for laboratory experiments:

Sl. No.	
1.	Pyranometer
2.	Solar panel
3.	Solar Cooker
4.	Solar Pump
5.	PV-Batter Set

E X A M I N A T I O N S C H E M E (SESSIONAL)

1. Continuous Internal Assessment of 50 marks is to be carried out by the teachers throughout the second Semester. Distribution of marks: Performance of Job – 30, Notebook – 20.

2. External Assessment of 50 marks shall be held at the end of the Third Semester on the entire syllabus. One Experiment per student from any one of the above is to be performed. Experiment is to be set by lottery system. Distribution of marks: On spot job – 30, Viva-voce – 20.

Maulana Abul Kalam Azad University of Technology, West Bengal
(Formerly West Bengal University of Technology)
Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course:M.Tech in Renewable Energy

Subject: Renewable Energy Lab II

Course Code: MRE 292	**Semester: 2**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory:	End Semester Exam:
Tutorial:	Teacher's Assessment:
Practical: 4 hrs/wk	Internal Assessment:
Credit: 02	Practical Sessional internal continuous evaluation: 50
	Practical Sessional external examination: 50

Practical:

Skills to be developed:

Intellectual skills:

1. Measurement of different parameters related to renewable energy.
2. Process of different measurement schemes

Motor Skills:

1. Proper handling of solar instruments.
2. Data collection schemes

List of Practical:

1. Performance analysis of windturbine.

2. Energy generation from fuelcell.

3. Energy generation frombio-digester.

4. Synthesis of bio diesel and itscharacteristics.

5. Characterization and testing of rechargeablebattery

Assignments:

List of equipment/apparatus for laboratory experiments:	
Sl. No.	
1.	Wind turbine set up
2.	Bio-digester
3.	Fuel cell
4.	Ammeter, Voltmeter
5.	Magnetic stirrer

E X A M I N A T I O N S C H E M E (SESSIONAL)

1. Continuous Internal Assessment of 50 marks is to be carried out by the teachers throughout the second Semester. Distribution of marks: Performance of Job – 30, Notebook – 20.

2. External Assessment of 50 marks shall be held at the end of the Third Semester on the entire syllabus. One Experiment per student from any one of the above is to be performed. Experiment is to be set by lottery system. Distribution of marks: On spot job – 30, Viva-voce – 20.

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course:M.Tech in Renewable Energy

Subject: Seminar

Course Code: MRE 281	**Semester: 2**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory:	End Semester Exam:
Tutorial:	Teacher's Assessment:
Practical: 2 hrs/wk	Internal Assessment:
Credit: 02	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Practical:

Skills to be developed:

Intellectual skills:

1.Students will be able to gather knowledge of different research topics while preparing for seminar.

Motor Skills:

1.Students will be able to learn technique & strategies deliver their view in front of audience.
2.
3.

List of Practical:

Assignments:

A topic will be allotted to individual student according to his/her subject of interest which may lead to his subject of dissertation in the 3rd semester. A thorough report based on the literature review on the topic is to be submitted by the student before presenting it as a seminar. Assessment of the student would be done on the basis of quality of presentation, performance in the question - answer session and the report submitted in presence of a panel of faculty members constituted by Departmental Academic Committee.

Maulana Abul Kalam Azad University of Technology, West Bengal
(Formerly West Bengal University of Technology)
Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Curriculum Structure

MAKAUT												
TEACHING AND EXAMINATION SCHEME FOR M.TECH COURSE												
COURSE NAME: RENEWABLE ENERGY												
COURSE CODE : MRE												
DURATION OF COURSE : 2 YEARS												
SEMESTER:THIRD SEMESTER						SCHEME :						
Sr. No.	SUBJECT Code	SUBJECT	PERIODS			EVALUATION SCHEME						Credits
THEORY			L	T	P	SESSIONSAL EXAM			ESE	PR(I NT.)	PR (EX T.)	
						TA	CT	Total				
1	MRE301	Research methodology and Intellectual Property right	02	01	--	15	15	30	70	--	--	3
2	MRE302	Renewable energy policy and regulation	02	01	--	15	15	30	70	--	--	3
3	MRE303	Renewable Energy Management, sustainability and cost analysis	02	01	--	15	15	30	70	--	--	3
4	MRE304I/II/ III	Recent advances in solar photovoltaics/ Composite Materials for Energy applications/ Environmental Impact Assessment	02	01	--	15	15	30	70	--	--	3
5	MRE381	Internship/Industrial Project	--	--	01	--	--	--	--	--	--	6

STUDENT CONTACT HOURS PER WEEK: 30
THEORY AND PRACTICAL PERIODS OF 60 MINUTES EACH

ABBREVIATIONS: CT- Class Test, TA - Teachers Assessment, L - Lecture, T - Tutorial, PR (INT.) – Practical (Internal) PR(EXT.)- Practical(External), ESE - End Semester Exam.

TA: Attendance & surprise quizzes = 6 marks. Assignment & Group Discussion = 4 marks.

Minimum passing for sessional marks is 40%, and for theory subject 40%.

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Maulana Abul Kalam Azad University of Technology, West Bengal
(Formerly West Bengal University of Technology)
Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course:M.Tech in Renewable Energy **Subject:Research methodology and Intellectual Property Rights**			
Course Code:MRE 301		**Semester: 3**	
Duration: One Semester		**Maximum Marks: 100**	
Teaching Scheme		**Examination Scheme**	
Theory: 2 hrs/wk		End Semester Exam: 70	
Tutorial: 1 hr/wk		Teacher's Assessment: 15	
Practical:		Internal Assessment: 15	
Credit:3		Practical Sessional internal continuous evaluation:	
		Practical Sessional external examination:	
Aim:			
Sl. No.			
1.	This subject find utility in understanding concepts & gather knowledge about the different aspects and application of distributed generation & smart grids.		
Objective:			
Sl. No.	The students will able		
1.	to understand research problemformulation		
2.	to analyze research related information		
3.	to Follow researchethics		
Pre-Requisite:			
Sl. No.			
1.	Power system, Energy resources		
Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours /Unit**	**Marks**
01	Introduction to research; Definitions and characteristics of research; Types of research; Main components of any research work. Analysis and Statement of the problem: Learning Objectives; Analyzing the	**12**	**15**

	problem; Formulating the problem statement. Literature review: Uses of literature review; Source of information; Aims & Objectives, Formulation and Scheduling of Objectives; Definitions; of the research objectives. Basic Quality Management tools and Acceptance Sampling, NumericalProblems.		
02	Development of Research Hypotheses, Data Collection — Primary and Secondary Data, Determination of Sample Size. Testing of Hypotheses, Null and Alternate hypothesis, One tailed and two –tailed test, Type I and Type II error, Steps in Testing Hypothesis, Basic concepts of Descriptive Statistics, Basic concepts of Design of Experiments. Numerical Problems.	**12**	**20**
03	Basic Spreadsheet tools: Introduction to spread-sheet applications, features & functions, using formulae & functions, data storing, features for statistical data analysis, generating charts/graphs & other features. Basic Presentation tool: Introduction to presentation tool, features & functions, creating presentations Basic Concepts of Web Search: search engines using for research data bases, Basics of Thesis writing editing tools. Writing style of Reference and Nomenclature	**12**	**20**
04	Introduction to Detailed Project Report – Incorporating Technical, Marketing, Environment, Social, Financial Part. How to study DPR. Basic Concepts of Feasibility Analysis Basics of IPR, Methodology of filling patents, follow up action. Basics of Network Analysis and Scheduling, NumericalProblems.	**12**	**15**
	Sub Total:	**48**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**

List of Books

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
Kothari C.K.	Research Methodoloy – Methods and Techniques		New Age International, NewDelhi
Krishnswamy, K.N., Shivkumar, Appalyer and Mathiranjan M.	Management Research Methodology;		Pearson Education, New Delhi

	Integration of Principles, Methods and Techniques		

End Semester Examination Scheme. Maximum Marks-70. Time allotted-3hrs.

Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)		**Subjective Questions**			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

- Only multiple choice type question (MCQ) with one correct answer are to be set in the objective part.
- Specific instruction to the students to maintain the order in answering objective questions should be given on top of the question paper.

Maulana Abul Kalam Azad University of Technology, West Bengal
(Formerly West Bengal University of Technology)
Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course:M.Tech in Renewable Energy **Subject:Renewable Energy Policy and Regulation**	
Course Code:MRE 302	**Semester: 3**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs/wk	End Semester Exam: 70
Tutorial: 1 hr/wk	Teacher's Assessment: 15
Practical:	Internal Assessment: 15
Credit: 3	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Aim:

Sl. No.	
1.	This subject find utility in understanding concepts & gather knowledge about the different aspects of energy policy & regulation

Objective:

Sl. No.	The students will able
1.	to identify the overall policy, regulatory and institutional framework on RenewableEnergy
2.	to analyze the main drivers that influence Renewable Energy policyformulation
3.	to identify different energy regulatory authorities across the globe.

Pre-Requisite:

Sl. No.	
1.	Power system, Energy resources

Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours /Unit**	**Marks**
01	Introduction to overall policy environment on energy sector along with policy formulation such as – per capita electricity Consumption, % electrification, GDP, total installed capacity, generation mix and the	**12**	**15**

	overall power sector structure, Entities – Consumers and their tariffs, generator, DISCOM, Regulators- Central Electricity Regulatory Commissions (CERC) & State Electricity Regulatory Commissions (SERC), Statutory bodies, SLDC, RLDC, NLDC, CTU, STU, CEA. Typical issues of Indian power sector – Cross Subsidization, Theft of electricity, Transmission losses etc		
02	An Introduction to Indian Renewable Energy Policy, National Solar Missions, Wind Power, National Wind-Solar hybrid policy by MNRE; Regulatory Commissions, Grid Code, Green Corridor, Solar Parks, Hybrid Parks, Repowering, Offshore, Scheduling and Forecasting, Electricity Trading, Open Access, RPO Distributed Generation Regional Grid in the South Asian Region; Electrification and off grid status/scenario in India; Scenario evolving with competitive bidding. National Action Plan on climate Change.	**12**	**20**
03	Scope and challenges in implementing off grid solutions Policy & regulatory Framework for rural electrification Micro and Mini grids; Relevant policies and frameworks in other countries; Recent off grid programs started by Govt. of India for enhancing the rural electrification through off-grid solutions; Decentralized Distributed Generation (DDG) scheme under Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY); Remote Village Electrification Program Village Energy Security Programme (VESP) Off grid programme under Jawaharlal Nehru National Solar Mission (JNNSM)	**12**	**20**
04	International regulation of renewable energy; the role of international law and economics in renewable power; Sustainable Energy for All (SE4ALL) Mission; Renewable energy and international trade law; A case study with the first Biogas Bottling Plant towards commercialization in India by Bio-energy Technology Development Group- BGFP; A case study with the 5MW solar project in Anantapura, AP, India highlighting the impact on local environment and related policy making.	**12**	**15**
	Sub Total:	**48**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**

List of Books

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
Dirk Abmann	Renewable Energy: A Global Review of Technologies, Policies and Markets		Earthscan Publications, UK, 2007
Stellina Jolly, Amit Jain	Climate Change: Changing Dimensions of Law and Policy		M D Publications Pvt. Ltd, India, 2009
Henrik Lund	Renewable Energy Systems: A Smart Energy Systems Approach to the Choice and Modelling of 100% Renewable Solutions		Academic Press, USA, 2014
Lawrence E. Jones	Renewable Energy Integration: Practical Management of Variability, Uncertainty, and Flexibility in Power Grids		Academic Press, USA, 2017

End Semester Examination Scheme. **Maximum Marks-70.** **Time allotted-3hrs.**

Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)		**Subjective Questions**			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks

A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

- Only multiple choice type question (MCQ) with one correct answer are to be set in the objective part.
- Specific instruction to the students to maintain the order in answering objective questions should be given on top of the question paper.

Name of the Course:M.Tech in Renewable Energy **Subject:Renewable Energy Management, Sustainability and Cost Analysis**	
Course Code:MRE 303	**Semester: 3**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs/wk	End Semester Exam: 70
Tutorial: 1 hr/wk	Teacher's Assessment: 15
Practical:	Internal Assessment: 15
Credit: 3	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Aim:

Sl. No.	
1.	This subject find utility in understanding concepts & gather knowledge about the different aspects of energy management and sustainability

Objective:

Sl. No.	The students will able
1.	to match energy usage with energy requirements and optimize input energyrequirements
2.	to prepare specific questionnaires and perform special tests for gathering data about energy usage for a particular energysystem
3.	to identify the technologies pertaining to sustainable and renewable energyapplication

Maulana Abul Kalam Azad University of Technology, West Bengal
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Pre-Requisite:			
Sl. No.			
1.	Power system, Energy resources, Environmental pollutions		
Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours /Unit**	**Marks**
01	A brief on green-house effect; Kyoto Protocol, Clean Development Mechanism (CDM); Afforestation and Reforestation projects, Reduced Emissions from Deforestation and Degradation (REDD); Life cycle analysis of CCS technologies; Pre and Post combustion capture; CO2 trapping mechanism and geological storage; CO2 fluid properties and interaction with rocks; Wettability, capillary pressure and relative permeability; Impact of impurities on rock and fluid properties; Application of CO2 in retrieving geothermal energy; Energy generation for CO2 to methane formation through catalytic process; Economic analysis of the power generationprocess.	**12**	**15**
02	Energy Audit, types of energy audit; Energy Audit approach: optimizing the input energy requirement; Energy audit instruments. Energy Management: Concept of energy management, energy demand and supply, economic analysis; Duties and responsibilities of energy managers, Energy conservation Act. Energy Conservation: Energy conservation in Household, Transportation, Agricultural, service and Industrial sectors, Lighting, Heating Ventilation & Air Conditioning. Energy Action Planning, Monitoring and Targeting, Tariffs and Power factor improvement in power system, Demand Side management concept, Energy Efficient practices.	**12**	**20**
03	Concepts of Green Building, Energy Conservation Building Code (ECBC), Framed Construction, Masonry Construction, Fenestration and glazings, Resources for Building Materials, Alternative concepts, Green Composites for buildings: Concepts of Green Composites. Water Utilization in Buildings, Low Energy Approaches to Water Management.Rain water harvesting, Management of Solid Wastes, Management of Sullage Water and Sewage.Mosquito nuisances and its removal, Urban Environment and Green Buildings. Green Cover and Built Environment, Recycling of Industrial and Buildings Wastes. Biomass Resources for buildings, Solar heat gain system and related area, HVAC, CaseStudies.	**12**	**20**

04	Comfort in Green Building, Solar passive Architecture, Thermal Comfort in Buildings, Issues, Incidence of Solar Heat on Buildings- Implications of Geographical Locations, Concepts of Solar Passive Cooling and Heating of Buildings, Low Energy Cooling, Natural ventilation and Louvre system; Utility of Solar energy in buildings, Solar Panel on windows and roof, Applications of Illumination engineering, Use of LED, Case studies of Solar Passive Cooled and Heated Buildings. Approaches for Certification of GreenBuilding.	**12**	**15**
	Sub Total:	**48**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**

List of Books

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
Stephen A.Rackley	Carbon Capture and Storage, 1st edition		Butterworth-Heinemann,2010.
Ursula Eicker	Low Energy Cooling For Sustainable Buildings		John Wiley and Sons Ltd,2009.
C.B. Smith	Energy Management Principles		Pergamon Press

End Semester Examination Scheme. Maximum Marks-70. Time allotted-3hrs.

Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)	**Subjective Questions**

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

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Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course:M.Tech in Renewable Energy **Subject:Recent Advances in Solar Photovoltaics**	
Course Code: MRE 304 I (Elective)	**Semester: 3**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs/wk	End Semester Exam: 70
Tutorial: 1 hr/wk	Teacher's Assessment: 15
Practical:	Internal Assessment: 15
Credit: 3	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Aim:

Sl. No.	
1.	This subject find utility in understanding concepts & gather knowledge about the different aspects of advances in solar photovoltaics

Objective:

Sl. No.	The students will able
1.	to gather knowledge of new materials for solarcells
2.	to understand different new solar cellstructures.
3.	To familiar with different process technologies of advanced solar cells.

Pre-Requisite:

Sl. No.	
1.	Solar cells, semiconductor

Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours /Unit**	**Marks**
01	Advanced Concepts: Fundamental limits on conversion efficiency, Shockley-Queisser theory, Multiple Junction solar cells, Quantum dot solar cells, Intermediate band solar cells, Photon splitting and multi-	**12**	**15**

	application High efficiency c-Si solar cells, losses in solar cells; optical, electrical, ways to overcome the losses, concept of selective emitter, N-type and P-type cells, alternative surface recombination, alternative metallization, novel cell structures, metal wrap through cells, point contacts, buried contact cell, PERL cell, HIT cells, Thin film silicon cells.		
02	Concepts of thin film, thin film deposition techniques, CVD, PECVD, sputtering, Physics of amorphous and nano-crystalline Si and alloys transport properties, Defect density and recombination, Structural considerations, Optical properties, Staebler-Wronski effect, Single and multi-junction solar cells, Deposition and manufacturing techniques, From cell to module, Advanced Thin film solar cells (CdTe, CIGS), Electrical and optical properties of materials, solar cell structure, principle of operation, material deposition techniques, cell performance, Multi-junction III-V solarcells.	**12**	**20**
03	Introduction to III-V Compound semiconductors and Hetero-structures, Single junction III-V cell: Design considerations, Tandem cells: Design considerations, Characterization of multi- junction solar cells: special, requirements, Multi-junction Concentrator solar cells, synthesis techniques, pseudomorphic structures, Organic Solar cells, Physics of organic semiconductors, Transport properties Photo-conduction and Luminescence Defects, Hetero- junction solar cells, Small molecule and polymer cells, Physics of degradation of organic cells, Fabrication techniques and manufacturing Sensitized solarcells.	**12**	**20**
04	Basic photoelectrochemistry, double layer concept, Band bending to flat, band transformation, semiconductor-liquid junction, charge and ion, transport, band bending/flat/slant in nanocrystalline materials, diffusion and ballistic transport, hot electron, photoelectrochemical solar cell, effect of electrolyte, Dye sensitized, solar cell, Charge transport mechanism, Characterization techniques, (Carrier lifetime, microwave conductivity, Kelvin probe SPV/CPD etc.), Solid state DSSC - problems and solutions, Semiconductor sensitized solar cells - advantages and disadvantages, solid state hole conductor, Nano-porous oxidesemiconductor	**12**	**15**
	Sub Total:	**48**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**
List of Books			

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Text Books/ Reference Books:

Name of Author	Title of the Book	Edition/ISSN/ISBN	Name of the Publisher
C. S. Solanki	Solar Photovoltaics: Fundamentals, Technologies and Applications		Prentice Hall of India,2011
H. J. Moller	Seminconductors for solar cells		Artech House Inc, MA, USA,1993
Sydney, M. Green	Silicon solar cells: advanced principles and practice		Bridge Printery,1995.
Barbec, V.Dyakonov, J.Parisi, N.S.Saricittci,	Organic photovoltaics: Concepts and realization		Springer-Verlag2003

End Semester Examination Scheme. **Maximum Marks-70.** **Time allotted-3hrs.**

Group	Unit	Objective Questions (MCQ only with the correct answer)		Subjective Questions			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

- Only multiple choice type question (MCQ) with one correct answer are to be set in the objective part.
- Specific instruction to the students to maintain the order in answering objective questions should be given on top of the question paper.

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course:M.Tech in Renewable Energy **Subject:Composite Materials for Energy Applications**	
Course Code: MRE 304 II (Elective)	**Semester: 3**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs/wk	End Semester Exam: 70
Tutorial: 1 hr/wk	Teacher's Assessment: 15
Practical:	Internal Assessment: 15
Credit: 3	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Aim:

Sl. No.	
1.	This subject find utility in understanding concepts & gather knowledge about the different aspects of composite materials

Objective:

Sl. No.	The students will able
1.	to know about the behaviour of constituents in the composite materials.
2.	to understand different types ofreinforcement
3.	to gather skills about different manufacturing methods of compositematerials

Pre-Requisite:

Sl. No.	
1.	Chemical behaviour of different materials

Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours /Unit**	**Marks**
01	Definition,Classification and characteristics of Composite materials. Advantage and application of composites, Functional requirements of reinforcement and matrix phases, Effect of reinforcement (size,	**12**	**15**

	shape, orientation, volume fraction) on overall performance		
02	Reinforcements: Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kelvarfibers and Boron fibers, Al2O3, SiC Whiskers, Properties and applications of whiskers, particle reinforcements, Mechanicalbehaviour of composites: Rule of mixtures, Inverse rule of mixtures, Isostrain and Isostress conditions.	**12**	**20**
03	Metal Matrix Composites: Al2O3fibre reinforced aluminium alloy, Solid state diffusion, sintering and hot isostatic pressing, Properties and applications. Manufacturing of Ceramic Matrix Composites, Preparation of Carbon-Carbon composites, Properties and applications.	**12**	**20**
04	Polymer Matrix Composites: Preparation of Glass fibre reinforced polymer composites, Carbon fibre reinforced polymer composites, Aramid or Kelvarfibre reinforced polymer composites, Nano clay-polymer composite.	**12**	**15**
	Sub Total:	**48**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**

List of Books

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
R.W.Cahn	Material Science and Technology		VCH, West Germany
WD Callister Jr.	Materials Science and Engineering, An introduction		John Wiley & Sons. NY, Indian edition,2007

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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

End Semester Examination Scheme. Maximum Marks-70. Time allotted-3hrs.

Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)		**Subjective Questions**			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

- Only multiple choice type question (MCQ) with one correct answer are to be set in the objective part.
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Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course:M.Tech in Renewable Energy **Subject:Environmental Impact Assessment**	
Course Code: MRE 304 III (Elective)	**Semester: 3**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory: 2 hrs/wk	End Semester Exam: 70
Tutorial: 1 hr/wk	Teacher's Assessment: 15
Practical:	Internal Assessment: 15
Credit: 3	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Aim:

Sl. No.	
1.	This subject find utility in understanding concepts & gather knowledge about the different aspects of environmental impact assessment

Objective:

Sl. No.	The students will able
1.	to identify the Basics of Environmental Engg. Principles need for carrying outEIA.
2.	to analyze different technologies and Legislations/Rules
3.	to conduct EIAStudies

Pre-Requisite:

Sl. No.	
1.	Chemical behaviour of different materials

Contents(Theory)		**Hrs./week**	
Unit	**Name of the Topic**	**Hours /Unit**	**Marks**
01	Basics of environmental problems associated with Renewable Energy Engineering. Sustainable technology and Renewable Energy Engineering, Genesis of environmental statutory body in India (Water	**12**	**15**

	act 1974). Legislative aspects, Environmental clearance for Renewable Energy Industries—Consent to Establish, Consent to Operate. Environmental standards and Threshold limits, EPA 1986.Air pollution aspects from conventional power plants, Sampling and analysis of air pollutants, Green house effect and global warming, Carbon foot print, general discussion on its reduction by the use of renewable energy devices.		
02	Problems of water pollution in renewable energy industries. Effluent treatment plant, trickling filter, RBDC and RBRC, oxidation ditches, WSP, Root zone and Reed bed treatments .Combined Sewage & Effluent treatment plant along with canteen waste for bio-gasgeneration.	**12**	**20**
03	Solid waste & E-waste management in Renewable Energy Industries: Sources and classification, public health aspects, Methods of collection and disposal methods. Recycling and reuse of components of renewable energy devices. Hazardous aspects associated with solar PV, Solar thermal, Hydro-power, Nuclear Power, Wind mill, OTEC, Geothermal energy, Bio-energy –casestudies.	**12**	**20**
04	Environmental Impact Assessment for renewable energy industries– Rain water harvesting, structural hazards, hazards associated with illumination engineering – CFL versus LED lights. Energy analysis and energy efficiency compliances. Case studies on use of renewable energy devices for reducing carbon foot print- Analysis of energy saving using solar PV and hybrid system—desalination, hot water production, sewage treatment in vehicular system, solar passive architecture and green building. Carbon trading, sequestration and carbon credit.	**12**	**15**
	Sub Total:	**48**	**70**
	Internal Assessment Examination & Preparation of Semester Examination		**30**
	Total:		**100**

List of Books

Text Books/ Reference Books:

Name of Author	**Title of the Book**	**Edition/ISSN/ISBN**	**Name of the Publisher**
Tiwari, G N & Ghosal, M K	Renewable Energy Resources—Basic Principles and		Narosa Publishing House, New Delhi, 2006

	Applications		
APHA & AWWA	Standard Methods		
	CPHEEO Manual 2015		GOI Publications

End Semester Examination Scheme. Maximum Marks-70. Time allotted-3hrs.

Group	**Unit**	**Objective Questions** (MCQ only with the correct answer)		**Subjective Questions**			
		No of question to be set	Total Marks	No of question to be set	To answer	Marks per question	Total Marks
A	**1,2,3,4**	**10**	10				**70**
B	**1,2,3,4**			**5**	**3**	**5**	
C	**1,2,3,4**			**5**	**3**	**15**	

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Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course:M.Tech in Renewable Energy **Subject: Internship/ Industrial Project**	
Course Code: MRE 381	**Semester:3**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory:	End Semester Exam:
Tutorial:	Teacher's Assessment:
Practical:1hr/week	Internal Assessment:
Credit: 06	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Practical:

Skills to be developed:

Intellectual skills:

1.

Motor Skills:

1.

2.

3.

Assignments:

Each student shall be required under the supervision of a faculty/ joint supervision of a faculty and an external expert to prepare an interim project work after carrying out investigation on an academic/industrial research problem. The research work has to be carried out by the student himself occasionally consulting his supervisor(s). The work has to be allotted to the student at the beginning of the 3rd semester. The interim report in duplicate has to be submitted in typed and bound form 7 days before commencement of the 3rdsemester examination. Assessment would be made on the basis of the submitted report and the viva voce examination conducted by a board of examiners constituted by the Departmental Academic Committee consisting of two faculty members and the supervisor and an external examiner with Head of the Department as Chairman during 3rd Semester examination.

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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Curriculum Structure

MAKAUT													
TEACHING AND EXAMINATION SCHEME FOR M.TECH COURSE													
COURSE NAME: RENEWABLE ENERGY													
COURSE CODE : MRE													
DURATION OF COURSE : 2 YEARS													
SEMESTER:FOURTH SEMESTER						SCHEME :							
Sr. No	SUBJECT Code	SUBJECT	PERIODS			EVALUATION SCHEME							Credits
Practical			L	T	P	SESSIONSAL EXAM			ESE	PR(INT.)	PR (EXT.)		
						TA	CT	Total					
1	MRE481	Research project	--	--	--	--	--	--	--	--	--		12
2	MRE482	Grand viva	--	--	--	--	--	--	--	--	--		2

STUDENT CONTACT HOURS PER WEEK: --
THEORY AND PRACTICAL PERIODS OF 60 MINUTES EACH

ABBREVIATIONS: CT- Class Test, TA - Teachers Assessment, L - Lecture, T - Tutorial, PR (INT.) – Practical (Internal) PR(EXT.)- Practical(External), ESE - End Semester Exam.

TA: Attendance & surprise quizzes = 6 marks. Assignment & Group Discussion = 4 marks.

Minimum passing for sessional marks is 40%, and for theory subject 40%.

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Maulana Abul Kalam Azad University of Technology, West Bengal
(Formerly West Bengal University of Technology)
Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course:M.Tech in Renewable Energy **Subject: Research Project**	
Course Code: MRE 481	**Semester: 4**
Duration: One Semester	**Maximum Marks:**
Teaching Scheme	**Examination Scheme**
Theory:	End Semester Exam:
Tutorial:	Teacher's Assessment:
Practical:	Internal Assessment:
Credit:12	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Practical:

Skills to be developed:

Intellectual skills:

Motor Skills:

1.
2.
3.

Assignments:

Each student shall be required to carry out and complete the research work that has been assigned to him at the beginning of 3rd semester under the supervision of a faculty / joint supervision of a faculty and an external expert. The research work has to be carried out by the student himself occasionally consulting his supervisor(s). The report in duplicate has to be submitted in typed and bound form 7 days before the commencement of the 4th semester examination. Assessment would be made on the basis of the submitted report and seminar presentation followed by viva voce examination conducted by a board of examiners constituted by the Departmental Academic Committee consisting of at least two faculty members, supervisor and an external examiner with Head of the Department as Chairman during 4th Semester examination.

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Syllabus for M. Tech in Renewable Energy (In-house)
(Applicable from the academic session 2019-2020)

Name of the Course:M.Tech in Renewable Energy **Subject: Grand Viva**	
Course Code: MRE 482	**Semester: 4**
Duration: One Semester	**Maximum Marks: 100**
Teaching Scheme	**Examination Scheme**
Theory:	End Semester Exam:
Tutorial:	Teacher's Assessment:
Practical:	Internal Assessment:
Credit: 02	Practical Sessional internal continuous evaluation:
	Practical Sessional external examination:

Practical:

Skills to be developed:

Intellectual skills:

Motor Skills:

1.
2.
3.

List of Practical:

Assignments:

This is a Viva – Voce examination to ascertain the student's overall grasp of the principles of Renewable energy engineering and allied fields. Students may be asked to give presentation on a topic of his choice for the assessment of his teaching skill. Assessment would also be made on the basis of the viva voce examination conducted by a board of examiners constituted by the Departmental Academic Committee consisting of at least three faculty members with Head of the Department as Chairman during 4th Semester examination