

ANNA UNIVERSITY, CHENNAI
NON-AUTONOMOUS AFFILIATED COLLEGES
REGULATIONS 2021

M. E. ENVIRONMENTAL ENGINEERING

CHOICE BASED CREDIT SYSTEM

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

Graduates of the Programme **M. E Environmental Engineering** will

- PEO1 Gain knowledge and skills in environmental engineering which will enable them to have a career and professional accomplishment in the public or private sector organisations
- PEO2 Become consultants on complex real life Environmental Engineering problems related to water supply, sewerage, sewage treatment, solid waste management, air pollution control, environmental impact assessment, industrial pollution control.
- PEO3 Become entrepreneurs and develop processes and technologies to meet desired environmental protection needs of society and formulate solutions that are technically sound, economically feasible, and socially acceptable.
- PEO4 Perform investigation for solving environmental problems by conducting research using modern equipment and software tools.
- PEO5 Function in multi-disciplinary teams and advocate policies, systems, processes and equipment for control and remediation of pollution.

2. PROGRAMME OUTCOMES (POs)

PO #	Graduate Attribute	Programme Outcomes
1	Research Aptitude	An ability to independently carry out research/investigation and development work to solve practical problems
2	Technical documentation	An ability to write and present a substantial technical report/document
3	Technical competence	Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

3. PROGRAMME SPECIFIC OUTCOMES (PSOs)

	Graduate Attribute	PROGRAMME SPECIFIC OUTCOMES (PSOs)
1	Handle complex problems	Use research based knowledge, methods, appropriate techniques, resources and tools to solve complex engineering issues with an understanding of the limitations.
2	Environmental Sustainability and societal Ethics	Ensure development of socially relevant and eco-friendly indigenous products by applying technical knowledge, ethical principles and sound engineering practices
3	Life-long learning	Recognize the need for independent, life-long learning and engage in the broadest context of technological change.

PEO/PO Mapping:

PEO	PO & PSO					
	PO1	PO2	PO3	PSO1	PSO2	PSO3
I.	1	1	3	3	1	2
II.	1	1	3	3	3	1
III.	2	2	3	3	2	1
IV.	3	2	3	2	2	1
V.	1	1	2	2	2	1

(3-High, 2- Medium, 1- Low)



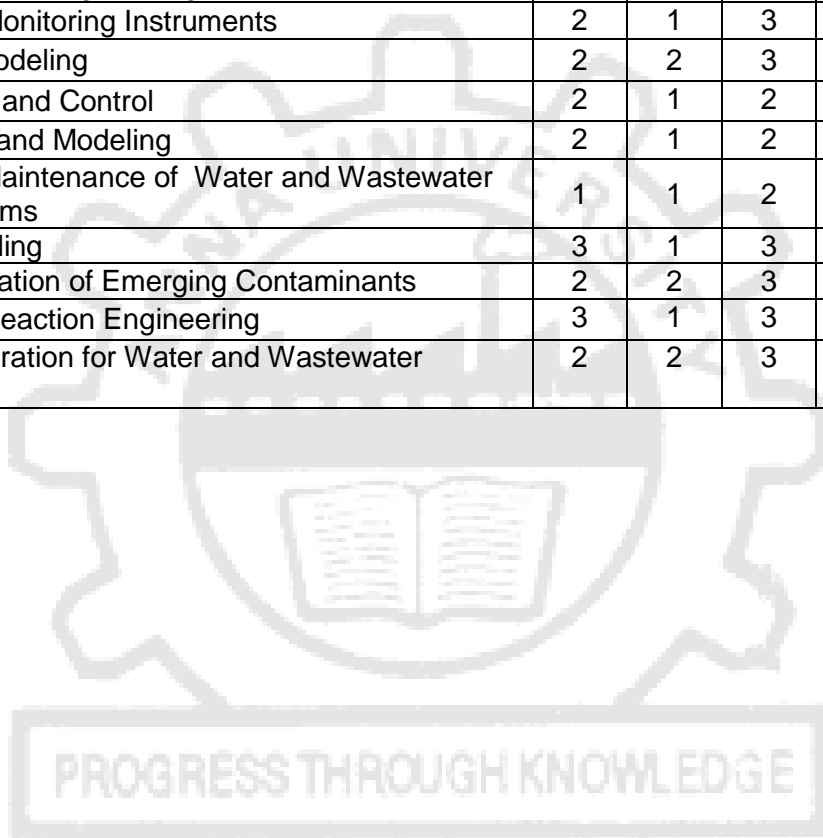
MAPPING OF COURSE OUTCOME AND PROGRAMME OUTCOME

		COURSE NAME	PO1	PO2	PO3	PSO1	PSO2	PSO3
YEAR I	SEMESTER I	Statistical Methods For Engineers	1.6	0.8	2.6	-	-	
		Environmental Chemistry	2	1	3	2	2	1
		Environmental Microbiology	3	1	2	2	2	1
		Physical and Chemical Treatment systems for water and wastewater	2	1	3	2	3	1
		Water transmission, water distribution and sewerage systems	1	1	3	3	2	1
		Research Methodology and IPR	2	2	3	2	2	2
		Audit Course I*	-	-	-	-	-	-
		Environmental Chemistry Laboratory	2	1	3	3	1	2
	Environmental Microbiology Laboratory	2	2	3	2	2	1	
	SEMESTER II	Biological Treatment process for Wastewater	3	3	3	2	2	2
		Air and Noise Pollution Control Engineering	3	2	3	3	2	2
		Industrial Wastewater Pollution- Prevention and Control	3	2	3	2	2	2
		Professional Elective I	-	-	-	--	-	-
		Professional Elective II	-	-	-	--	-	-
Professional Elective III		-	-	-	--	-	-	
Audit Course –II		-	-	-	--	-	-	
Environmental and Processes Monitoring Laboratory		3	2	3	2	2	1	
YEAR II	SEMESTER III	Program Elective IV	-	-	-	--	-	-
		Program Elective V	-	-	-	--	-	-
		Open Elective	-	-	-	--	-	-
		Technical Seminar-	-	-	-	--	-	-
		Industrial Training (2 Weeks)	-	-	-	--	-	-
		Project Work I	-	-	-	--	-	-
	SEMESTER IV	Project Work II	-	-	-	--	-	-

PROGRESS THROUGH KNOWLEDGE

PROGRAM ELECTIVE COURSES [PEC]

S. NO.	COURSE TITLE	PO1	PO2	PO3	PSO1	PSO2	PSO3
1.	Solid and hazardous waste management	2	1	3	3	3	2
2.	Natural Systems for Wastewater Treatment	2	1	3	2	3	1
3.	Environmental System Analysis	2	1	3	2	1	1
4.	Environmental impact Assessment	3	3	3	3	2	2
5.	SEPTAGE and Onsite wastewater treatment technologies	2	1	3	1	2	2
6.	Sustainability Engineering	1	1	3	2	3	1
7.	Project formulation and implementation	2	2	3	3	1	1
8.	Advanced Oxidation Process	2	2	3	2	1	1
9.	Computing Techniques in Environmental Engineering	1	2	3	3	2	2
10.	Geo Environmental Engineering	2	1	3	3	1	1
11.	Environmental Monitoring Instruments	2	1	3	3	2	2
12.	Water Quality Modeling	2	2	3	3	1	1
13.	Marine Pollution and Control	2	1	2	3	2	2
14.	Climate change and Modeling	2	1	2	2	1	1
15.	Operation and Maintenance of Water and Wastewater Treatment Systems	1	1	2	3	2	1
16.	Air Quality Modeling	3	1	3	3	2	1
17.	Fate and remediation of Emerging Contaminants	2	2	3	3	1	1
18.	Environmental Reaction Engineering	3	1	3	2	1	1
19.	Membrane Separation for Water and Wastewater Treatment	2	2	3	3	2	1



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CHOICE BASED CREDIT SYSTEM
I TO IV SEMESTERS CURRICULA AND SYLLABUS
SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA4159	Statistical Methods for Engineers	FC	4	0	0	4	4
2.	EV4101	Environmental Chemistry	PCC	3	0	0	3	3
3.	EV4102	Environmental Microbiology	PCC	3	0	0	3	3
4.	EV4103	Physical and Chemical Treatment Systems for Water and Wastewater	PCC	3	0	0	3	3
5.	EV4104	Water Transmission, Water Distribution and Sewerage Systems	PCC	3	0	0	3	3
6.	RM4151	Research Methodology and IPR	RMC	2	0	0	2	2
7.		Audit Course I*	AC	2	0	0	2	0
PRACTICALS								
8.	EV4111	Environmental Chemistry Laboratory	PCC	0	0	4	4	2
9.	EV4112	Environmental Microbiology Laboratory	PCC	0	0	4	4	2
TOTAL				20	0	8	28	22

* Audit Course is optional

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	EV4201	Biological Treatment Process for Wastewater	PCC	3	0	0	3	3
2.	EV4202	Air and Noise Pollution Control Engineering	PCC	3	0	0	3	3
3.	EV4203	Industrial Wastewater Pollution-Prevention and Control	PCC	3	0	0	3	3
4.		Professional Elective I	PEC	3	0	0	3	3
5.		Professional Elective II	PEC	3	0	0	3	3
6.		Professional Elective III	PEC	3	0	0	3	3
7.		Audit Course II*	AC	2	0	0	2	0
PRACTICALS								
8.	EV4211	Environmental and Processes Monitoring Laboratory	PCC	0	0	6	6	3
TOTAL				20	0	6	26	21

* Audit Course is optional

SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Professional Elective IV	PEC	3	0	0	3	3
2.		Professional Elective V	PEC	3	0	0	3	3
3.		Open Elective	OEC	3	0	0	3	3
PRACTICALS								
4.	EV4311	Technical Seminar	EEC	0	0	2	2	1
5.	EV4312	Industrial Training (2 Weeks)	EEC	0	0	0	0	1
6.	EV4313	Project Work I	EEC	0	0	12	12	6
TOTAL				9	0	14	23	17

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	EV4411	Project Work II	EEC	0	0	24	24	12
TOTAL				0	0	24	24	12

TOTAL CREDITS: 72

FOUNDATION COURSES (FC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	MA4159	Statistical Methods for Engineers	4	0	0	4	1

PROFESSIONAL CORE COURSES (PCC)

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	EV4101	Environmental Chemistry	3	0	0	3	1
2.	EV4102	Environmental Microbiology	3	0	0	3	1
3.	EV4103	Physical and Chemical Treatment Systems for Water and Wastewater	3	0	0	3	1
4.	EV4104	Water Transmission, Water Distribution and Sewerage Systems	3	0	0	3	1
5.	EV4111	Environmental Chemistry Laboratory	0	0	4	2	1
6.	EV4112	Environmental Microbiology Laboratory	0	0	4	2	1
7.	EV4201	Biological Treatment process for Wastewater	3	0	0	3	2
8.	EV4202	Air and Noise Pollution Control Engineering	3	0	3	3	2
9.	EV4203	Industrial Wastewater Pollution-Prevention and Control	3	0	0	3	2
10.	EV4211	Environmental and Processes Monitoring Laboratory	0	0	6	3	2
TOTAL						28	

LIST OF PROFESSIONAL ELECTIVE COURSES [PEC]**SEMESTER II, ELECTIVE I**

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	P		
1.	EV4001	Solid and Hazardous Waste Management	3	0	0	3	3
2.	EV4002	Natural Systems for Wastewater Treatment	3	0	0	3	3
3.	EV4003	Environmental System Analysis	3	0	0	3	3

SEMESTER II, ELECTIVE II

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	P		
1.	EV4004	Environmental Impact Assessment	3	0	0	3	3
2.	EV4005	Septage and Onsite Wastewater Treatment Technologies	3	0	0	3	3
3.	EV4006	Sustainability Engineering	3	0	0	3	3
4.	EV4007	Project Formulation and Implementation	3	0	0	3	3

SEMESTER II, ELECTIVE III

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	P		
1.	EV4008	Advanced Oxidation Process	3	0	0	3	3
2.	EV4009	Computing Techniques in Environmental Engineering	3	0	0	3	3
3.	EV4010	Geo Environmental Engineering	3	0	0	3	3
4.	EV4011	Environmental Monitoring Instruments	3	0	0	3	3

SEMESTER III, ELECTIVE IV

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	P		
1.	EV4012	Water Quality Modeling	3	0	0	3	3
2.	EV4013	Marine Pollution and Control	3	0	0	3	3
3.	EV4014	Climate Change and Modeling	3	0	0	3	3
4.	EV4015	Operation and Maintenance of Water and Wastewater Treatment Systems	3	0	0	3	3

SEMESTER III, ELECTIVE V

S NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	P		
1.	EV4016	Air Quality Modeling	3	0	0	3	3
2.	EV4017	Fate and Remediation of Emerging Contaminants	3	0	0	3	3
3.	EV4018	Environmental Reaction Engineering	3	0	0	3	3
4.	EV4019	Membrane Separation for Water and Wastewater Treatment	3	0	0	3	3

RESEARCH METHODOLOGY AND IPR COURSES (RMC)

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	RM4151	Research Methodology and IPR	2	0	0	2	1
TOTAL CREDITS						2	

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	EV4311	Technical Seminar	0	0	2	1	3
2.	EV4312	Industrial Training (2 Weeks)	0	0	0	1	3
3.	EV4313	Project Work I	0	0	12	6	3
4.	EV4411	Project Work II	0	0	24	12	4
TOTAL CREDITS						20	

AUDIT COURSES (AC)

Registration for any of these courses is optional to students

S. NO	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	AX4091	English for Research Paper Writing	2	0	0	0	1/2
2.	AX4092	Disaster Management	2	0	0	0	
3.	AX4093	Constitution of India	2	0	0	0	
4.	AX4094	நற்றமிழ் இலக்கியம்	2	0	0	0	

LIST OF OPEN ELECTIVES FOR PG PROGRAMMES

SL. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS
			L	T	P	
1.	OIC431	Blockchain Technologies	3	0	0	3
2.	OIC432	Deep Learning	3	0	0	3
3.	OME431	Vibration and Noise Control Strategies	3	0	0	3
4.	OME432	Energy Conservation and Management in Domestic Sectors	3	0	0	3
5.	OME433	Additive Manufacturing	3	0	0	3
6.	OME434	Electric Vehicle Technology	3	0	0	3
7.	OME435	New Product Development	3	0	0	3
8.	OBA431	Sustainable Management	3	0	0	3
9.	OBA432	Micro and Small Business Management	3	0	0	3
10.	OBA433	Intellectual Property Rights	3	0	0	3
11.	OBA434	Ethical Management	3	0	0	3
12.	ET4251	IoT for Smart Systems	3	0	0	3
13.	ET4072	Machine Learning and Deep Learning	3	0	0	3
14.	PX4012	Renewable Energy Technology	3	0	0	3
15.	PS4093	Smart Grid	3	0	0	3
16.	CP4391	Security Practices	3	0	0	3
17.	MP4251	Cloud Computing Technologies	3	0	0	3
18.	IF4072	Design Thinking	3	0	0	3
19.	MU4153	Principles of Multimedia	3	0	0	3
20.	DS4015	Big Data Analytics	3	0	0	3
21.	NC4201	Internet of Things and Cloud	3	0	0	3
22.	MX4073	Medical Robotics	3	0	0	3
23.	VE4202	Embedded Automation	3	0	0	3
24.	CX4016	Environmental Sustainability	3	0	0	3
25.	TX4092	Textile Reinforced Composites	3	0	0	3
26.	NT4002	Nanocomposite Materials	3	0	0	3
27.	BY4016	IPR, Biosafety and Entrepreneurship	3	0	0	3

PROGRESS THROUGH KNOWLEDGE

SUMMARY

S. No.	Name of the Programme: M.E. ENVIRONMENTAL ENGINEERING					
	SUBJECT AREA	CREDITS PER SEMESTER				CREDITS TOTAL
		I	II	III	IV	
1.	FC	04	00	00	00	04
2.	PCC	16	12	0	00	28
3.	PEC	00	9	6	00	15
4.	RMC	02	00	00	00	02
5.	OEC	00	00	3	00	03
6.	EEC	00	00	08	12	20
7.	Non Credit/Audit Course	✓	✓	00	00	00
8.	TOTAL CREDIT	22	21	17	12	72



OBJECTIVES :

- This course is designed to provide the solid foundation on topics in various statistical methods which form the basis for many other areas in the mathematical sciences including statistics, modern optimization methods and risk modeling. It is framed to address the issues and the principles of estimation theory, testing of hypothesis, correlation and regression, design of experiments and multivariate analysis.

UNIT I ESTIMATION THEORY**12**

Estimators : Unbiasedness, Consistency, Efficiency and sufficiency – Maximum likelihood estimation – Method of moments.

UNIT II TESTING OF HYPOTHESIS**12**

Sampling distributions - Small and large samples -Tests based on Normal, t, Chi square, and F distributions for testing of means, variance and proportions – Analysis of r x c tables – Goodness of fit.

UNIT III CORRELATION AND REGRESSION**12**

Multiple and partial correlation – Method of least squares – Plane of regression – Properties of residuals – Coefficient of multiple correlation – Coefficient of partial correlation – Multiple correlation with total and partial correlations – Regression and partial correlations in terms of lower order co-efficient.

UNIT IV DESIGN OF EXPERIMENTS**12**

Analysis of variance – One way and two way classifications – Completely randomized design – Randomized block design – Latin square design - 2^2 Factorial design.

UNIT V MULTIVARIATE ANALYSIS**12**

Random vectors and matrices – Mean vectors and covariance matrices – Multivariate normal density and its properties – Principal components : Population principal components – Principal components from standardized variables.

TOTAL: 60 PERIODS**OUTCOMES :**

After completing this course, students should demonstrate competency in the following topics:

- Consistency, efficiency and unbiasedness of estimators, method of maximum likelihood estimation and Central Limit Theorem.
- Use statistical tests in testing hypotheses on data.
- Concept of linear regression, correlation, and its applications.
- List the guidelines for designing experiments and recognize the key historical figures in Design of Experiments.
- Perform exploratory analysis of multivariate data, such as multivariate normal density, calculating descriptive statistics, testing for multivariate normality.

The students should have the ability to use the appropriate and relevant, fundamental and applied mathematical and statistical knowledge, methodologies and modern computational tools.

REFERENCES :

- Gupta.S.C., and Kapoor, V.K., "Fundamentals of Mathematical Statistics", 12th Edition, Sultan Chand and Sons, 2020.
- Jay L. Devore, "Probability and statistics for Engineering and the Sciences", 8th Edition, Cengage Learning, 2014.
- Johnson, R.A., Miller, I and Freund J., "Miller and Freund's Probability and Statistics for Engineers", 9th Edition, Pearson Education, Asia, 2016.

4. Johnson, R.A. and Wichern, D. W. "Applied Multivariate Statistical Analysis", 6th Edition, Pearson Education, Asia, 2012.
5. Rice, J.A. "Mathematical Statistics and Data Analysis", 3rd Edition, Cengage Learning, 2015.

COs- PO's & PSO's MAPPING

	PO01	PO02	PO03	PO04	PO05	PO06
CO1	2	1	3	-	-	-
CO2	2	1	3	-	-	-
CO3	2	1	3	-	-	-
CO4	-	-	1	-	-	-
CO5	2	1	3	-	-	-
Avg.	1.6	0.8	2.6	-	-	-

EV4101

ENVIRONMENTAL CHEMISTRY

L T P C
3 0 0 3

OBJECTIVES:

- To educate the students in the area of water, air and soil chemistry
- To explain the theoretical basis and observational methods for study of contaminants and interactions in the environment

UNIT I FUNDAMENTALS

9

Stoichiometry and mass balance-Chemical equilibria, acid base, solubility product(Ksp), heavy metal precipitation, amphoteric hydroxides, CO₂ solubility in water and species distribution – Ocean acidification, Chemical kinetics, First order- 12 Principles of green chemistry.

UNIT II AQUATIC CHEMISTRY

11

Water and wastewater quality parameters- environmental significance and determination; Fate of chemicals in aquatic environment, volatilization, partitioning, hydrolysis, photochemical transformation– Degradation of synthetic chemicals - Metals, complex formation, oxidation and reduction, pE – pH diagrams, redox zones – sorption- Colloids, electrical properties, double layer theory, environmental significance of colloids, coagulation.

UNIT III ATMOSPHERIC CHEMISTRY

7

Atmospheric structure – chemical and photochemical reactions – photochemical smog. Ozone layer depletion – greenhouse gases and global warming, CO₂ capture and sequestration – acid rain- origin and composition of particulates. black carbon, air quality parameters determination.

UNIT IV SOIL CHEMISTRY

9

Nature and composition of soil - Clays- cation exchange capacity-acid base and ion-exchange reactions in soil – agricultural chemicals in soil-reclamation of contaminated land; salt by leaching- Heavy metals by electrokinetic remediation.

UNIT V EMERGING POLLUTANTS

9

Heavy metals-chemical speciation –Speciation of Hg & As- endocrine disturbing chemicals- Pesticides, Dioxins & Furan, PCBs, PAHs and Fluoro compounds toxicity- Nano materials, CNT, titania, composites, environmental applications.

TOTAL: 45 PERIODS

OUTCOMES:

CO1: Students will gain competency in solving environmental issues of chemicals based pollution

CO2: Ability to determine chemicals mobility in aquatic systems

CO3: Ability to identify contaminating chemicals in air and their fate

CO4: Understand the type of soil contaminants and provide remediation

CO5: Identify emerging environmental contaminants including speciation

REFERENCES:

1. Sawyer, C.N., Mac Carty, P.L. and Parkin, G.F., "Chemistry for Environmental Engineering and Science", Tata McGraw – Hill, Fifth edition, New Delhi 2003.
2. Colin Baird,, Environmental Chemistry, Freeman and company, New York, 5th Edition,2012.
3. Manahan, S.E., "Environmental Chemistry", Ninth Edition, CRC press, 2009.
4. Ronald A. Hites , "Elements of Environmental Chemistry", Wiley, 2nd Edition,2012.

COs- PO's & PSO's MAPPING

CO	PO			PSO		
	1	2	3	1	2	3
1	3	1	2	-	2	1
2	2	1	3	3	2	1
3	2	1	2	2	2	1
4	2	1	3	2	2	-
5	2	2	3	2	2	1

EV4102**ENVIRONMENTAL MICROBIOLOGY****L T P C
3 0 0 3****OBJECTIVES:**

- To provide a basic understanding on microbiology relevant to environmental engineering for candidates.
- To gain knowledge on morphology, behaviour and biochemistry of bacteria, fungi, protozoa, viruses, and algae .
- To understand the microbiology of wastewater, sewage sludge and solid waste treatment processes. And to understand the aspects of nutrient removal and the transmission of disease causing organisms .
- To have an exposure to toxicology due to industrial products and byproducts .

UNIT I FUNDAMENTALS OF MICROBIOLOGY**10**

Classification of microorganisms – prokaryotic, eukaryotic, cell structure, characteristics, importance, introduction to water, soil and air borne pathogens and Parasites and their effects on human, animal and plant health, transmission of pathogens, transmissible diseases – bacterial, viral, protozoan, and helminths parasites, concentration and detection of virus. Control of microorganisms preservation of microorganisms, DNA, RNA, replication, recombinant DNA technology, their potential applications and intellectual property rights.

UNIT II MICROBIAL DIVERSITY AND NUTRIENT TURNOVER**10**

Distribution of microorganisms in different environments – diversity of microorganisms – fresh and marine, terrestrial – microbes in surface soil, air – outdoor and Indoor, aerosols, bio safety in laboratory – extreme environment – archae bacteria – occurrence in water supplies – problems and control. biogeochemical cycles-nitrogen, carbon, phosphorus, sulphur – Role of Microorganism in nutrient cycle.

UNIT III METABOLISM OF MICROORGANISMS**9**

Nutrition and metabolism in microorganisms, growth phases, carbohydrate, protein, lipid metabolism – respiration, aerobic and anaerobic-fermentation, glycolysis, Kreb's cycle, hexose monophosphate pathway, electron transport system, oxidative phosphorylation, environmental factors, enzymes, bioenergetics, disruption in metabolism and disease. biodegradation of organic pollutants

UNIT IV MICROBIOLOGY OF WASTEWATER TREATMENT SYSTEMS**8**

Microbiology of biological treatment processes – aerobic and anaerobic, α -oxidation, β -oxidation, nitrification and denitrification, eutrophication. nutrients removal – BOD, nitrogen, phosphate.

microbiology of sewage sludge - indicator organisms of water – coliforms - total coliforms, E-coli, streptococcus, clostridium, Bioleaching

UNIT V TOXICOLOGY

8

Ecotoxicology – toxicants and toxicity, factors influencing toxicity. Effects – acute, chronic, test organisms – toxicity testing-lab and field testing methods, bioconcentration – Bioaccumulation, biomagnification, bioassay, biomonitoring.

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to
- CO1** Explain the basic importance and functional elements of environmental microbiology including the potential applications in the environment and intellectual property rights.
- CO2** Understand and describe the type of microorganisms in the environment, their importance in water supplies and the role of microorganisms in the cycling of nutrients in an ecosystem.
- CO3** Understand the metabolic processes on carbohydrates, protein and lipids, importance of enzymes, production of energy and the various additional metabolic processes.
- CO4** Select and apply appropriate methods for assessing the water, air and soil borne pathogens, their health implications, and importance of microbes in aerobic and anaerobic cycles and deterioration of water bodies.
- CO5** Conduct testing and research on toxicology, understand the importance of test organisms, environmental applications such as biomagnifications, biomonitoring and in developing risk based standards.

REFERENCES:

1. Bhatia S.C. "Hand Book of Environmental Microbiology", Part 1 and 2, Atlantic Publisher, 2008
2. Gabriel Bitton, Wastewater Microbiology, 2nd Edition, 3. Raina M. Maier, Ian L. Pepper, Charles P. Gerba, "Environmental Microbiology", Academic Press, 2000
4. Volodymyr Ivanov, Environmental Microbiology for Engineers 2nd Edition, CRC Press, 2015, ISBN 9781498702126
5. Nduka Okafor, Environmental Microbiology of Aquatic and Waste systems. Springer Publishers, 2011, ISBN 978-94-007-1459-5
6. Stanley E. Manahan, "Environmental Science and Technology", Lewis Publishers, 2008.
7. Hurst, C.J. Manual of "Environmental Microbiology". 2nd Ed. ASM PRESS, Washington, D.C. ISBN 1-55581 - 199 - X. 2002
8. Frank C. Lu and Sam Kacew, LU's Basic Toxicology, Taylor & Francis, London 4th Ed, 2002.

COs- PO's & PSO's MAPPING

CO	PO			PSO		
	1	2	3	1	2	3
1	3	1	2	1	1	1
2	3	1	3	3	2	1
3	3	1	2	1	3	1
4	2	1	2	2	2	2
5	3	2	3	2	2	1

EV4103

PHYSICAL AND CHEMICAL TREATMENT SYSTEMS FOR WATER AND WASTEWATER

**L T P C
3 0 0 3**

OBJECTIVE:

- To understand about the various pollutants present in water and wastewater and to choose the respective physico-chemical systems for effective treatment

- To apply the knowledge for municipal, industrial water and wastewater treatment plants and design suitable treatment schemes
- To gain advance knowledge on the emerging environmental issues on treatment systems and conduct research to identify most appropriate treatment schemes

UNIT I INTRODUCTION 5

Pollutants in water and wastewater–characteristics, standards for performance- significance of physico-chemical treatment–Selection criteria-types of reactor-reactor selection-batch-continuous type-kinetics

UNIT II TREATMENT PRINCIPLES 10

Physical treatment - screening – mixing, equalization –sedimentation – filtration – evaporation–incineration–gas transfer–mass transfer coefficient adsorption – isotherms – membrane separation, Reverse Osmosis, nanofiltration, ultrafiltration and electro dialysis, distillation– stripping and crystallization – recent advances.

Principles of Chemical treatment– Coagulation - flocculation–Precipitation – flotation - solidification and stabilization–Disinfection, Ion exchange, Electrolytic methods, Solvent extraction–advanced oxidation/reduction– recent trends

UNIT III DESIGN OF MUNICIPAL WATER TREATMENT PLANTS 10

Selection of treatment–design of municipal water treatment plant units–aerators–chemical feeding–flocculation–clarifier–tube settling–filters–rapid sand filters, slow sand filter, pressure filter, dual media filter – disinfection flow charts– layouts –hydraulic profile ,PID-construction and O&M aspects–case studies, residue management – upgradation of existing plants – recent trends.

UNIT IV DESIGN OF INDUSTRIAL WATER TREATMENT PLANTS 10

Design of industrial water treatment units-selection of process–design of softeners –demineralisers–Reverse osmosis plants–flow charts–layouts–hydraulic profile, PID-construction and O&M aspects–case studies, residue management–upgradation of existing plants –recent trends.

UNIT V DESIGN OF WASTEWATER TREATMENT PLANTS 10

Design of municipal wastewater treatment units-screens- grit chamber-settling tanks- sludge thickening - sludge dewatering systems - sludge drying beds - design of industrial wastewater treatment units - equalization - neutralization - chemical feeding devices – mixers - floatation units - oil skimmer - flowcharts – layouts – hydraulic profile, PID, construction and O&M aspects – case studies, retrofitting - residue management – upgradation of existing plants – recent trends.

TOTAL: 45 PERIODS

OUTCOME:

- On Completion of the course, the student is expected to be able to

CO1 Explain the significance of various pollutants present in water, wastewater and develop the kinetics for reactor design

CO2 Choose the relevant physico-chemical systems for effective water and wastewater treatment

CO3 Design the treatment scheme for municipal and industrial water, wastewater to meet the specific needs on residue management and up gradation of existing plants

CO4 Identify environmental issues in the society on wastewater treatment and formulate technical solutions that are economically feasible and socially acceptable

CO5 Conduct research to identify and design most appropriate treatment schemes for the emerging environmental issues on treatment systems in collaboration with municipalities, corporation, pollution control boards and industries

REFERENCES:

1. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017
2. Lee, C.C. and Shun dar Lin, "Handbook of Environmental Engineering Calculations", McGraw Hill, New York, 1999.
3. Qasim.S.R., Guang Zhu., "Wastewater Treatment and Reuse" – Volume 1& 2 2018.

4. CPHEEO manual – “Manual for sewerage and sewage treatment systems” – Part A,B,C, Ministry of Urban development, New Delhi,2013.
5. CPHEEO manual – “Manual for water supply and treatment” –Ministry of Urban development, New Delhi, 1999.

COs- PO's & PSO's MAPPING

CO	PO			PSO		
	1	2	3	1	2	3
1	2	1	3	2	3	1
2	1	1	3	2	3	1
3	1	1	3	2	3	1
4	2	1	3	2	3	1
5	2	2	3	3	3	1

EV4104 WATER TRANSMISSION, WATER DISTRIBUTION AND SEWERAGE SYSTEMS

L T P C
3 0 0 3

OBJECTIVE:

- To educate the students on economic design of water mains, distribution system and sewer networks

UNIT I GENERAL HYDRAULICS

8

Fluid properties; fluid flow – continuity principle, energy principle and momentum principle; frictional head loss in free and pressure flow, minor head losses, carrying capacity– flow measurement. need for transport of water and wastewater and types

UNIT II WATER TRANSMISSION MAINS

9

Planning of water system – design of storage reservoirs - water transmission main design- compound gravity and pumping main; selection of pumps and characteristics curve - economics; specials, jointing, laying and maintenance, water hammer analysis;

UNIT III WATER DISTRIBUTION

9

Service reservoirs-types and design. water distribution pipe networks design, analysis and optimization – appurtenances – corrosion prevention – minimization of water losses – leak detection. plumbing for water supply in high rise buildings. use of computer software in water transmission, water distribution design – EPANET 2.0, LOOP version 4.0, BRANCH,

UNIT IV WASTEWATER COLLECTION AND CONVEYANCE

10

Planning factors – design of sanitary sewer; partial flow in sewers, economics of sewer design; wastewater pumps and pumping stations- sewer appurtenances; material, construction, inspection and maintenance of sewers; design of sewer outfalls-mixing conditions; conveyance of corrosive wastewaters. plumbing for drains in high rise buildings

UNIT V STORM WATER DRAINAGE

9

Necessity- combined and separate system; estimation of storm water runoff - formulation of rainfall intensity duration and frequency relationships- rational methods. use of computer software in sewer design–sewer. SewerCAD, SewerGEMS

TOTAL: 45 PERIODS

OUTCOMES:

- On Completion of the Course the student will be able to

CO1	Understand general hydraulics and need for proper collection and conveyance of water and wastewater
CO2	Design economic diameters of gravity and pumping mains and storage reservoirs

CO3	Design and analysis of water distribution networks and apply computer softwares
CO4	Design sewer networks for various flow conditions
CO5	Design storm water drain and apply computer softwares for design of sewers.

REFERENCES:

1. Pramod R. Bhave, Rajesh Gupta. "Analysis of Water Distribution Networks", Alpha Science International, 2006
2. Bajwa, G.S. "Practical Handbook on Public Health Engineering", Deep Publishers, Shimla, 2003
3. "Manual on water supply and Treatment", CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 1999.
4. "Manual on Sewerage and Sewage Treatment Part-A Engineering", CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013

COs- PO's & PSO's MAPPING

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	1	2	3	1	2	3
1	2	-	3	2	2	1
2	1	1	3	3	1	1
3	1	1	3	3	2	1
4	1	1	3	3	1	1
5	1	1	3	3	2	1

RM4151

RESEARCH METHODOLOGY AND IPR

L T P C
2 0 0 2

UNIT I RESEARCH DESIGN 6

Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys.

UNIT II DATA COLLECTION AND SOURCES 6

Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.

UNIT III DATA ANALYSIS AND REPORTING 6

Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.

UNIT IV INTELLECTUAL PROPERTY RIGHTS 6

Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

UNIT V PATENTS 6

Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filing, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licences, Licensing of related patents, patent agents, Registration of patent agents.

TOTAL :30 PERIODS

REFERENCES

1. Cooper Donald R, Schindler Pamela S and Sharma JK, "Business Research Methods", Tata McGraw Hill Education, 11e (2012).
2. Catherine J. Holland, "Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets", Entrepreneur Press, 2007.

- David Hunt, Long Nguyen, Matthew Rodgers, "Patent searching: tools & techniques", Wiley, 2007.
- The Institute of Company Secretaries of India, Statutory body under an Act of parliament, "Professional Programme Intellectual Property Rights, Law and practice", September 2013.

EV4111

ENVIRONMENTAL CHEMISTRY LABORATORY

L T P C

0 0 4 2

OBJECTIVES:

- To train the students in the analysis of physico-chemical parameters with hands on experience .

1.	Good Laboratory Practices, Quality control, calibration of Glassware	8
2.	Sampling and Analysis of water (pH, alkalinity, hardness, chloride, Sulphate, turbidity EC, TDS,TS, nitrate, fluoride and Iron)	20
3.	Sampling and Wastewater analysis (BOD, COD, Phosphate, Ammonia, TKN, Oil & Grease, Surfactant and heavy metals)	20
4.	Sampling and characterization of soil (Moisture, EC, pH ,Na and K)	12

TOTAL: 60 PERIODS

OUTCOME:

CO1 : Ability to calibrate and standardize the equipments

CO2 : Ability to collect proper sample for analysis

CO3 : The candidate ability to perform field oriented testing of water, wastewater and soil

CO4 : Able to perform soil testing

CO5 : Able to perform analysis of water and wastewater

REFERENCES:

- APHA, "Standard Methods for the Examination of Water and Wastewater", 22nd Ed. Washington, 2012.
- "Laboratory Manual for the Examination of water, wastewater soil Rump", H.H. and Krist, H. – Second Edition, VCH, Germany, 3rd Edition, 1999.
- "Methods of air sampling & analysis", James P.Lodge Jr(Editor) 3rd Edition, Lewis publishers,Inc,USA,1989.

COs- PO's & PSO's MAPPING

CO	PO			PSO		
	1	2	3	1	2	3
1	1	-	2	2	1	3
2	1	1	2	2	1	3
3	2	1	3	3	1	1

EV4112

ENVIRONMENTAL MICROBIOLOGY LABORATORY

L T P C

0 0 4 2

OBJECTIVE:

- To train the students in the analysis of various microbiological techniques, microbiological analysis, enzyme assay, pollutant analysis and operation of bioreactors.

EXPERIMENTS:

- Preparation of culture media,
- Isolation and culturing of microorganisms
- Microscopical identification of Microorganisms (algae, bacteria and fungi)

4. Measurement of growth of microorganisms,
5. Analysis of air borne microorganisms,
6. Staining of bacteria.
7. Effect of pH, temperature on microbial growth
8. Bacteriological analysis of wastewater (Coliforms, *E.coli*, *Streptococcus*) – MPN
9. Bacteriological analysis of wastewater (Coliforms, *Streptococcus*) - MF techniques,
10. Effect of Heavy metals on microbial growth.
11. Detection of Anaerobic bacteria (*Clostridium* sp.)
12. Bioreactors (cultivation of microorganisms)

TOTAL: 60 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to

- CO1** Explain the basic importance and functional elements of environmental microbiology including the types of microorganisms in air, water and soil.
- CO2** Understand and describe the type of microorganisms in the environment, their importance and the method of culturing of microorganisms in the laboratory.
- CO3** Understand the basic biochemical method of identification of microorganisms and to identify them using microscopical tool.
- CO4** Select and apply appropriate methods for detection in the water, air and soil borne pathogens, their health implications, importance of microbes in our daily life.
- CO5** Conduct testing and research on toxicology, the importance of test organisms, environmental applications of such microorganisms in toxicological studies and in developing risk based standards.

REFERENCES:

1. APHA, "Standard Methods for the Examination of Water and Wastewater", 22nd Ed. Washington, 2012.
2. Charles P. Gerba, "Environmental Microbiology: A laboratory manual", Elsevier Publications, 2012.
3. Christon J. Hurst, Ronald L. Crawford, Jay L. Garland, David A. Lipson, Aaron L. Mills, and Linda D. Stetzenbach, "Manual of Environmental Microbiology", 3rd Edition, ASM Press, 2007.

COs- PO's & PSO's MAPPING

CO	PO			PSO		
	1	2	3	1	2	3
1	1	-	3	2	2	1
2	3	1	2	2	1	1
3	3	2	3	2	2	1

EV4201

BIOLOGICAL TREATMENT PROCESS FOR WASTEWATER

L T P C

3 0 0 3

OBJECTIVES:

- To educate the students on the principles and process designs of various treatment systems for wastewater
- To gain competency in the process employed in design of treatment systems and the components comprising such systems, leading to the selection of specific process.

UNIT I REACTION KINETICS AND BIO REACTORS

9

Objectives of biological treatment – significance – principles of aerobic and anaerobic treatment - kinetics of biological growth – factors affecting growth – attached and suspended growth - determination of kinetic coefficients for organics removal - enzyme kinetics biodegradability assessment - selection of process- reactors- biokinetics - batch reactor - continuous flow stirred tank reactor-plug flow reactor - flow charts, layout, PID, hydraulic profile

UNIT II CONVENTIONAL AEROBIC TREATMENT PROCESSES 9

Design of sewage treatment plant units –activated sludge process and variations - trickling filters- bio-tower- RBC- fluidized bed reactors, aerated lagoons, waste stabilization ponds – natural treatment systems, constructed wetland – nutrient removal systems- disposal options – reclamation and reuse – recent trends.

UNIT III ADVANCED AEROBIC TREATMENT PROCESSES OF WASTEWATER 9

Sequencing batch reactors- moving bed biofilm reactors- membrane bioreactor- reclamation and reuse of wastewater-design of tertiary treatment units-application of membrane separation technologies in reuse of sewage -nutrient removal systems-case studies

UNIT IV ANAEROBIC TREATMENT OF WASTEWATER 9

Attached and suspended growth process - design of units – UASB – post treatment systems for UASB reactor-anaerobic filters – expanded bed and fluidized bed anaerobic systems - septic tank and soil disposal system - anaerobic baffled reactor – design of nutrient removal systems - anaerobic ammonium oxidation process - recent trends.

UNIT V SLUDGE TREATMENT, OPERATION AND MAINTENANCE 9

Sources and its characteristics-design of sludge management facilities, sludge thickening- sludge digestion - biogas generation- sludge dewatering- mechanical – ultimate residue disposal – recent advances-construction and operational maintenance problems in STPs– trouble shooting – planning, organizing and controlling of plant operations – capacity building - retrofitting case studies

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to

CO1 Understand the microbial process and its kinetics

CO2 Design and size the different components of conventional aerobic treatment systems.

CO3 Design and size the different components of advanced aerobic treatment systems.

CO4 Understand in detail about the anaerobic treatment of wastewater which includes the design of attached and suspended growth processes.

CO5 Design the different elements of sludge treatment systems and understand the importance O&M issues pertaining to biological treatment systems

REFERENCES:

1. Arceivala S.J., and Asolekar S.R "Wastewater Treatment for Pollution Control and reuse "McGraw Hill , third Edition, New Delhi, 2007.
2. Manual for "Sewerage and Sewage Treatment Systems" CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013.
3. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017
4. Qasim, S. R. and Guang Zhu "Wastewater Treatment and Reuse. Theory and Design Examples", CRC Press, New York, 2018.
5. F.R. Spellman, "Hand Book of Water and Wastewater Treatment Plant operations", CRC Press, New York 2009.
6. David Hendricks, "Fundamentals of Water Treatment Process", CRC Press, New York 2011.

COs- PO's & PSO's MAPPING

CO	PO			PSO		
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1	2	-	3	2	1	1
2	3	3	3	2	1	1
3	3	3	3	2	1	1
4	3	2	3	2	2	2
5	2	2	3	3	2	3

OBJECTIVE:

- To impart knowledge on types and sources of air pollution, its effects and design of control methods

UNIT I INTRODUCTION**8**

Structure and composition of atmosphere – sources and classification of air pollutants – effects of air pollutants on human health, vegetation & animals, Materials & Structures – effects of air pollutants on the atmosphere, soil & water bodies – Longterm effects– global climate change, Ozone Holes – ambient air quality and emission standards – air pollution indices – emission inventories.

UNIT II AIR POLLUTION MONITORING AND MODELLING**8**

Ambient and stack sampling and analysis of particulate and gaseous pollutants -effects of meteorology on air pollution - fundamentals, atmospheric stability, inversion, wind profiles and stack plume patterns- transport & dispersion of air pollutants – modelling techniques – Air Pollution climatology.

UNIT III CONTROL OF PARTICULATE POLLUTANTS**10**

Factors affecting selection of control equipment; gas particle interaction, – working principle, design and performance equations of gravity separators, cyclones, Fabric filters, particulate scrubbers, electrostatic precipitators – operational considerations - costing of APC equipment – recent advances

UNIT IV CONTROL OF GASEOUS POLLUTANTS**10**

Factors affecting selection of control equipment -working principle, design and performance equations of absorption, adsorption, condensation, incineration, bio-scrubbers, bio-filters –control technologies-SO₂,NO_x CO, H₂S; process control and monitoring - operational considerations - costing of APC equipment –emerging trends,

UNIT V AUTOMOBILE AND NOISE POLLUTION**9**

Vehicular Pollution: Automobile emission- types of emissions- prevention and control of vehicular pollution.

Noise Pollution: Sources and effects of noise pollution – measurement – standards –control and preventive measures.

Indoor Air Pollution: Sources and effects –control and preventive measures

TOTAL: 45 PERIODS**OUTCOMES:**

After completion of this course, the student is expected to be able to understand:

- CO1** Various types and sources of air pollution and its effects
- CO2** Methods of source and ambient monitoring and dispersion of pollutants and their modeling
- CO3** The principles and design of control of particulate pollutants
- CO4** The principles and design of control of gaseous pollutant
- CO5** Sources, effects and control of vehicular, indoor air and noise pollution

REFERENCES:

- Noel de Nevers, "Air Pollution Control Engg", McGraw Hill, New York, 2016.
- Daniel Vallero "Fundamentals of Air Pollution", Fourth Edition, 2008.
- Arthur C.Stern, "Air Pollution (Vol.I – Vol.VIII)", Academic Press, 2006.
- Lawrence K. Wang, Norman C. Parelra, Yung Tse Hung, "Air Pollution Control Engineering", Tokyo, 2004.
- David H.F. Liu, Bela G. Liptak, "Air Pollution", Lweis Publishers, 2000.
- Wayne T.Davis, "Air Pollution Engineering Manual", John Wiley & Sons, Inc., 2000.

COs- PO's & PSO's MAPPING

CO	PO			PSO		
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1	2	2	3	3	3	2
2	3	2	3	2	2	2
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5	3	2	3	2	2	2

EV4203**INDUSTRIAL WASTEWATER POLLUTION - PREVENTION AND CONTROL****L T P C
3 0 0 3****OBJECTIVES:**

- To understand the principle of various processes applicable to industrial wastewater treatment
- To impart knowledge on the concept and application of Industrial pollution prevention, cleaner technologies, industrial wastewater treatment and residue management.
- To identify the best applicable technologies for wastewater treatment from the perspective of yield production.

UNIT I INTRODUCTION**8**

Industrial scenario in India– industrial activity and environment - uses of water by industry – sources and types of industrial wastewater – nature and origin of pollutants - industrial wastewater and environmental impacts – regulatory requirements for treatment of industrial wastewater – industrial waste survey – industrial wastewater monitoring and sampling - generation rates, characterization and variables – toxicity of industrial effluents and bioassay tests – major issues on water quality management.

UNIT II INDUSTRIAL POLLUTION PREVENTION & WASTE MINIMISATION**8**

Prevention vis a vis control of industrial pollution – benefits and barriers – waste management Hierarchy - source reduction techniques – periodic waste minimisation assessments – evaluation of pollution prevention options – cost benefit analysis – pay-back period – implementing & promoting pollution prevention programs in industries.

UNIT III INDUSTRIAL WASTEWATER TREATMENT**10**

Flow and load equalisation – solids separation – removal of fats, oil & grease- neutralisation-removal of inorganic constituents – precipitation, heavy METAL removal, nitrogen & phosphorous removal, Ion exchange, adsorption, membrane filtration, electro dialysis & evaporation – removal of organic constituents – biological treatment processes, chemical oxidation processes, advanced oxidation processes – treatability studies.

UNIT IV WASTEWATER REUSE AND RESIDUAL MANAGEMENT**9**

Individual and common effluent treatment plants – Joint treatment of industrial and domestic wastewater - zero effluent discharge systems - quality requirements for wastewater reuse industrial reuse , present status and issues - disposal on water and land – residuals of industrial wastewater treatment – quantification and characteristics of sludge – thickening, digestion, conditioning, dewatering and disposal of sludge – management of RO rejects.

UNIT V CASE STUDIES**10**

Industrial manufacturing process description, wastewater characteristics, source reduction options and waste treatment flow sheet for textiles – tanneries – pulp and paper – metal finishing – Oil refining–pharmaceuticals–sugar and distilleries

TOTAL: 45 PERIODS

OUTCOME:

- On Completion of the course, the student is expected to be able to
- CO1** Explain the source and types of industrial wastewater and their environmental impacts and choose the regulatory laws pertaining to environmental protection
- CO2** Identify industrial wastewater pollution and implement pollution prevention, waste minimization in industries
- CO3** Apply knowledge and skills to design industrial wastewater treatment schemes
- CO4** Audit and analyze environmental performance of industries to internal, external client, regulatory bodies and design water reuse management techniques
- CO5** Conduct research to develop effective management systems for industrial wastewater that are technically sound, economically feasible and socially acceptable

REFERENCES:

1. "Industrial wastewater management, treatment & disposal, Water Environment" Federation Alexandria Virginia, Third Edition, 2008.
2. Lawrence K. Wang, Yung Tse Hung, Howard H.Lo and Constantine Yapijakis "handbook of Industrial and Hazardous waste Treatment", Second Edition, 2004.
3. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017
4. Nelson Leonard Nemerow, " industrial waste Treatment", Elsevier, 2007.
5. Wesley Eckenfelder W., " Industrial Water Pollution Control", Second Edition, Mc Graw Hill, 2000.
6. Paul L. Bishop, Pollution Prevention: - Fundamentals and Practice', Mc-Graw Hill International, Boston, 2000.
7. Waste water Treatment for pollution control and reuse by Soli. J. Arceivala, Shyam. R. Asolekar, Tata McGraw Hill, 2007

COs- PO's & PSO's MAPPING

CO	PO			PSO		
	1	2	3	1	2	3
1	2	2	3	2	2	2
2	3	2	3	2	1	1
3	3	2	3	2	2	3
4	2	3	3	2	2	3
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PROGRESS THROUGH KNOWLEDGE

EV4211 ENVIRONMENTAL AND PROCESSES MONITORING LABORATORY L T P C
0 0 6 3

OBJECTIVE:

- To develop the skill for conducting treatability studies of water and wastewater and monitoring of ambient air and noise quality

Sl. No.	Name of Experiment	Hours
1.	Coagulation and Flocculation	6
2.	Batch studies on settling	6
3.	Studies on Filtration- Characteristics of Filter media	6
4.	Water softening	6
5.	Adsorption studies/Kinetics	6
6.	Langelier Saturation Index and Silt Density Index- For Membrane Filtration	6
7.	Kinetics of suspended growth process (activated sludge process)-and Sludge volume Index	12
8.	Sludge Filterability Test	6
9.	Anaerobic Reactor systems / kinetics (Demonstration)	6

10.	Advanced Oxidation Processes – (Photo catalysis)	6
11.	Disinfection for Drinking water (Chlorination)	6
12.	Ambient Air Sampling-Determination of PM10, PM2.5, SO ₂ and NO ₂	12
13.	Noise Monitoring-Determination of Equivalent Noise Level	6
TOTAL PERIODS		90

OUTCOME:

After the completion of the course the students will be able

CO1 To conduct treatability studies on water and wastewater treatment

CO2 To determine the removal / degradation of pollutants from water and wastewater and arrive at kinetics

CO3 To design scaled up reactors for treatment of water and wastewater treatment based on laboratory studies

CO4 To determine ambient air quality of given study area in terms of Particulate and Gaseous Pollutants

CO5 To determine Equivalent Noise Level by noise monitoring

REFERENCES:

1. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017
2. Lee, C.C. and Shundar Lin. "Handbook of Environmental Engineering Calculations", McGraw Hill, New York, 1999.
3. AEESP Environmental Processes Laboratory Manual, Association of Environmental Engineering and Science Professors Foundation, Washington, 2002.
4. Aery N C., "Manual of Environmental Analysis", Ane Books Pvt. Ltd. New Delhi, 2014
5. CPCB, Guidelines for the Measurement of Ambient Air Pollutants, Volume I, Central Pollution Control Board, Ministry of Environment and Forests, Government of India, 2001

COs- PO's & PSO's MAPPING

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	1	2	3	1	2	3
1	2	1	3	3	2	1
2	3	2	3	2	1	1
3	3	2	3	2	2	2

PROGRESS THROUGH KNOWLEDGE

EV4001

SOLID AND HAZARDOUS WASTE MANAGEMENT

L T P C

3 0 0 3

OBJECTIVE

- To impart knowledge and skills relevant to minimization, storage, collection, transport, recycling, processing and disposal of solid and hazardous wastes including the related regulations, engineering principles, design criteria, methods and equipment.

UNIT I WASTE CLASSIFICATION AND REGULATORY REQUIREMENTS

9

Sources and types of solid and hazardous wastes - need for solid and hazardous waste management – salient features of latest Indian legislations on management and handling of solid wastes, hazardous wastes, biomedical wastes, electronic wastes, construction and demolition wastes, plastics and discarded lead acid batteries – elements of integrated waste management and roles of stakeholders - seven elements and seven step approach to integrated solid waste management planning.

UNIT II WASTE CHARACTERIZATION, SOURCE REDUCTION AND RECYCLING 9

Waste sampling and characterization plan - waste generation rates and variation – physical composition, chemical and biological properties – hazardous characteristics – ignitability, corrosivity and TCLP tests –source reduction, segregation and onsite storage of wastes – waste exchange - extended producer responsibility - recycling of plastics, C&D wastes and E wastes.

UNIT III WASTE COLLECTION, TRANSPORT AND MATERIAL RECOVERY 9

Door to door collection of segregated solid wastes - analysis of hauled container and stationery container collection systems - compatibility, storage, labeling and handling of hazardous wastes – principles and design of transfer and transport facilities - hazardous waste transport and manifests - mechanical processing and material separation technologies – Size reduction – size separation - density separation - magnetic separation – compaction – principles and design of material recovery facilities – physico chemical treatment of hazardous wastes - solidification and stabilization – case studies on waste collection and material recovery

UNIT IV BIOLOGICAL AND THERMAL PROCESSING OF WASTES 9

Biological and thermo chemical conversion technologies – composting – biomethanation – incineration – pyrolysis- plasma arc gasification –principles and design of biological and thermal treatment facilities - MSW processes to energy with high-value products and specialty BY-Products - operation of facilities and environmental controls - treatment of biomedical wastes – case studies and emerging waste processing technologies.

UNIT V WASTE DISPOSAL 9

Sanitary and secure landfills - components and configuration– site selection - liner and cover systems - geo synthetic clay liners and geo membranes - design of sanitary landfills and secure landfills- leachate collection, treatment and landfill gas management – landfill construction and operational controls - landfill closure and environmental monitoring – landfill bioreactors – rehabilitation of open dumps and biomining of dumpsites-remediation of contaminated sites- Case studies

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to
- CO1** Explain the various functional elements of solid and hazardous waste management including the associated legal, health, safety, and cultural issues as well as responsibilities of different stakeholders
- CO2** Apply the knowledge of science and engineering fundamentals to characterize different types of solid and hazardous wastes, assess the factors affecting variation and assess performance of waste treatment and disposal systems
- CO3** Design of systems and processes to meet specified needs of waste minimization, storage, collection, transport, recycling, processing and disposal.
- CO4** Select appropriate methods for processing and disposal of solid and hazardous wastes, taking into account the impact of the solutions in a sustainability context
- CO5** Conduct research pertinent to solid and hazardous waste management and communicate effectively to different stakeholders as well as engage in independent life-long learning

REFERENCES:

1. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil, "Integrated Solid Waste Management, Mc-Graw Hill India, First edition, 2015.
2. CPHEEO, "Manual on Municipal Solid waste management, Vol I, II and III, Central Public Health and Environmental Engineering Organisation, Government of India, New Delhi, 2016.
3. William A. Worrell, P. Arne Vesilind, Christian Ludwig, Solid Waste Engineering - A Global Perspective, 3rd Edition, Cengage Learning, 2017.
4. Michael D. LaGrega, Philip L Buckingham, Jeffrey C. E vans and "Environmental Resources Management, Hazardous waste Management", Mc-Graw Hill International edition, New York, 2010.
5. John Pichtel, Waste Management Practices, CRC Press, Taylor and Francis Group, 2014.

6. Gary C. Young, Municipal Solid Waste to Energy Conversion Processes: Economic, Technical, and Renewable Comparisons, Wiley, 2010
7. Cherry P M, Solid and Hazardous Waste Management, CBS publishers and distributors Pvt Ltd, 2018
8. Rao M.N, Razia Sultana, Sri Harsha Kota, solid and hazardous waste management – Science and Engineering , Butterworth-Heinemann, 2016

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CO	PO			PSO		
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2	2	1	3	2	3	2
3	2	1	3	3	3	1
4	2	2	3	3	2	1
5	3	1	3	3	3	3

EV4002 NATURAL SYSTEMS FOR WASTEWATER TREATMENT L T P C
3 0 0 3

OBJECTIVE

- To gain knowledge and understanding of wetlands -types of wetland, constructed wetland - application, design, method of treatment of both domestic and industrial wastewaters and case studies.
- To gain knowledge on design, construction and operation of waste stabilization pond and sludge disposal.

UNIT I INTRODUCTION TO WETLAND TREATMENT SYSTEM 9

Definition and concept of wetland - types of wetland. Wetland - ecology, flora and fauna, ecological aspects, human health and wetland, onsite applications. introduction to constructed wetland-types-free water surface, subsurface wetland-horizontal and vertical flow- wastewaters and their application in wetland - constructed wetland plants-media – in constructed wetland.

UNIT II CONSTRUCTED WETLAND AND REMOVAL MECHANISMS 9

Site identification- construction and design of constructed wetland, startup, operation and maintenance of wetland system-wetland hydrology- hydraulics. Treatment of domestic wastewater and its performance, mechanisms of pollutant removal- suspended solids, organic matter, nitrogen, phosphorus, pathogen and other contaminants. Reuse of treated wastewater and its applications- limitation of constructed wetland system.

UNIT III CASE STUDIES ON CONSTRUCTED WETLAND SYSTEM 8

Constructed wetland- treatment of domestic wastewater- greywater - landfill leachate – treatment of industrial wastewaters- textile wastewater – dairy wastewater and its performance. Removal of specific pollutants such as heavy metals, aromatics and emerging contaminants etc. Use of amendments in wetland construction, and its performance. Capital and maintenance costs.

UNIT IV DESIGN OF WASTEWATER POND SYSTEMS. 10

Introduction- facultative -partial -mix aerated- ponds -complete -mix aerated pond systems - anaerobic ponds -nitrogen removal in lagoons. Modified high -performance aerated pond systems for nitrification and denitrification - nitrogen removal in ponds coupled with wetlands and gravel bed nitrification filters -Control of algae and design of settling basins. Hydraulic control of ponds -removal of phosphorous -removal of pharmaceuticals and personal care products and antibiotic resistant genes.

UNIT V SLUDGE MANAGEMENT AND TREATMENT 9

Sludge quantity and characteristics - stabilization and dewatering -sludge freezing -reed beds - vermi stabilization -comparison of bed type operations -composting land application and surface disposal

of bio solids onsite wastewater systems -effluent disposal and reuse. Sludge quantity and characteristics-stabilization and dewatering-sludge freezing reed beds-vermi stabilization-Comparison of bed-type operations-composting land application and surface disposal of biosolids-on-site wastewater systems- effluent disposal and reuse.

TOTAL : 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to
- CO1** Explain the various aspects of wetland system, its function and its application in the treatment of wastewaters
- CO2** Apply the knowledge of science and engineering fundamentals to know the types of wetlands, construction and operation of wetlands, wetland hydraulics and design of wetland and its performance Understand the process of treatment of domestic waste in the removal of solids, organic matter, phosphate, nitrogen, pathogens and its reuse
- CO3** Understand the process of treatment of industrial wastewater in the removal of solids, organic matter, phosphate, nitrogen, heavy metals, phenolics and feasibility for reuse
- CO4** Understand the various pond system available for wastewater treatment. design of pond system -removal mechanism
- CO5** Manage and dispose the sludge naturally and economically.

REFERENCES:

1. EPA- Design Manual on constructed wetland and aquatic plant system for municipal wastewater treatment system
2. Treatment wetlands by Robert .H.Kadlec, Scott Wallace , CRC press published July 22, 2008
3. Natural Wastewater Treatment Systems, Ronald W. Crites, E. Joe Middlebrooks, Robert K. Bastia, 2nd Edition, CRC PressPublished March 14, 2014
4. Waste water treatment in constructed wetlands with horizontal sub- surface flow by Jan Vyamazal and Lenka Kropfelova, Springer 2010.
5. Constructed wetlands for industrial wastewater treatment system by Alexandros I.Stefanakis (editor), Wiley black well.2018

COs- PO's & PSO's MAPPING

CO	PO			PSO		
	1	2	3	1	2	3
1	2	1	3	3	3	1
2	2	1	3	2	3	1
3	3	1	3	3	3	1
4	2	2	3	2	2	1
5	1	1	3	2	2	1

EV4003

ENVIRONMENTAL SYSTEM ANALYSIS

**L T P C
3 0 0 3**

OBJECTIVES:

- To introduce the modelling concept in various environmental field like ecological modelling, CSTR modelling and the kinetics of reaction
- To gain knowledge on river and stream water modelling and soft computing techniques.

UNIT I ECOLOGICAL SYSTEM

9

Basic concepts in ecology and ecological modelling, population dynamics: birth and death processes. Single species growth, prey-predator models: Lotka-Volterra, Rosenzweig-MacArther, Kolmogorov models. multi-species modeling - structural analysis and stability of complex ecosystems.

UNIT II REACTOR MODELLING 9

CSTR, plug-flow, dispersion. A case study of a tubular reactor with axial dispersion, parameter calibration: search algorithms for nonlinear dynamical models, variance of estimated parameters. application to Monod and Haldane kinetics.

UNIT III WATER QUALITY MODELLING 9

Rivers and streams water quality modeling -dispersion and mixing- water quality modelling process-model sensitivity-assessing model performance; models for dissolved oxygen and pathogens-pollutant and nutrient dynamics -dissolved oxygen dynamics -groundwater quality modeling.

UNIT IV MICROBIAL DYNAMICS AND ENERGETICS 9

Requirements for carbon and nutrient removal. Activated sludge: process schemes: completely mixed, plug-flow, SBR, nutrient removal. Anaerobic digestion: process dynamics, operational control of wastewater treatment processes.

UNIT V COMPUTER BASED SOLUTIONS 9

Formulation of linear optimization models. linear programming. sensitivity testing and duality. Solution techniques and computer programming; Formulation of linear optimization models. Application of models- simulation, parameter estimation and experimental design.

TOTAL: 45 PERIODS**OUTCOMES:**

- On completion of the course, the students are able to
- CO1 Apply the principle of system modeling
 CO2 Do reactor modeling
 CO3 Develop water quality models.
 CO4 Model microbial dynamics
 CO5 Apply the knowledge of numerical techniques to environmental system modeling

REFERENCES:

1. Deaton, M.L and Winebrake, J.J., "Dynamic Modeling of Environmental Systems", Springer-Verlag, 2000
2. Orhon, D and Artan, N., "Modeling of Activated Sludge Systems, Technomic" Publ. Co., 1994.
3. Steven C. Chapra, "Surface Water Quality Modelling", Tata McGraw-Hill Companies, Inc., New Delhi 2018.

COs- PO's & PSO's MAPPING

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1	1	2	3	3	1	1
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4	2	1	3	2	1	1
5	2	2	3	2	2	1

EV4004 ENVIRONMENTAL IMPACT ASSESSMENT**L T P C
3 0 0 3****OBJECTIVES:**

- To make the students to understand environmental clearance, its legal requirements and to provide knowledge on overall methodology of EIA, prediction tools and models, environmental management plan and case studies.

UNIT I INTRODUCTION 9

Historical development of Environmental Impact Assessment (EIA). Environmental Clearance- EIA in project cycle. legal and regulatory aspects in India – types and limitations of EIA –EIA process-screening – scoping - terms of reference in EIA- setting – analysis – mitigation. Cross sectoral issues –public hearing in EIA- EIA consultant accreditation.

UNIT II IMPACT IDENTIFICATION AND PREDICTION 10

Matrices – networks – checklists – cost benefit analysis – analysis of alternatives – expert systems in EIA. prediction tools for EIA – mathematical modeling for impact prediction – assessment of impacts – air – water – soil – noise – biological — cumulative impact assessment

UNIT III SOCIO-ECONOMIC IMPACT ASSESSMENT 8

Socio-economic impact assessment - relationship between social impacts and change in community and institutional arrangements. Factors and methodologies- individual and family level impacts. Communities in transition-rehabilitation

UNIT IV EIA DOCUMENTATION AND ENVIRONMENTAL MANAGEMENT PLAN 9

Environmental management plan - preparation, implementation and review – mitigation and rehabilitation plans – policy and guidelines for planning and monitoring programmes – post project audit – documentation of EIA findings – ethical and quality aspects of environmental impact assessment

UNIT V CASE STUDIES 9

Mining, power plants, cement plants, highways, petroleum refining industry, storage & handling of hazardous chemicals, common hazardous waste facilities, CETPs, CMSWMF, building and construction projects

TOTAL: 45 PERIODS**OUTCOMES:**

- On completion of the course, the student is expected to be able to

CO1 Understand need for environmental clearance, its legal procedure, need of EIA, its types, stakeholders and their roles

CO2 Understand various impact identification methodologies, prediction techniques and model of impacts on various environments

CO3 Understand relationship between social impacts and change in community due to development activities and rehabilitation methods

CO4 Document the EIA findings and prepare environmental management and monitoring plan

CO5 Identify, predict and assess impacts of similar projects based on case studies

REFERENCES:

1. EIA Notification 2006 including recent amendments, by Ministry of Environment, Forest and Climate Change, Government of India
2. Sectoral Guidelines under EIA Notification by Ministry of Environment, Forest and Climate Change, Government of India
3. Canter, L.W., Environmental Impact Assessment, McGraw Hill, New York. 1996
4. Lawrence, D.P., Environmental Impact Assessment – Practical solutions to recurrent problems, Wiley-Interscience, New Jersey. 2003
5. Lee N. and George C. 2000. Environmental Assessment in Developing and Transitional Countries. Chichester: Willey
6. World Bank –Source book on EIA ,1999
7. Sam Mannan, Lees' Loss Prevention in the Process Industries, Hazard Identification Assessment and Control, 4th Edition, Butterworth Heineman, 2012.

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1	1	1	2	2	3	1
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3	1	1	2	3	1	1
4	2	3	2	3	2	2
5	3	2	3	2	2	1

OBJECTIVE:

- To understand on the principles and process designs aspects of onsite sanitation and decentralized wastewater management systems.
- To gain competency in the process employed in sludge and septate management systems and the components comprising such systems, leading to the selection of specific process.

UNIT I URBANIZATION AND SANITATION 9

Sanitation Infrastructure in Urban India - Emerging Recognition of Faecal Sludge and Septage Management -Sanitation Service Chain -Faecal Sludge and Septage -Need for Faecal Sludge and Septage Management -Septage Management and Sewerage Systems -Components of Sanitation Value Chain- Approach to Septage Management in Cities

UNIT II DESLUDGING AND CONVEYANCE OF SEPTAGE 9

Planning for Emptying Services - Current Status of Emptying Services -Need for Periodic Cleaning of Septic Tanks - Prohibition of Employment as Manual Scavengers and their Rehabilitation Act-Technologies for Desludging - Parameters for Assessing Conveyance Options - Demand Based Desludging - Schedule Based Desludging - Private Sector Participation .

UNIT III SEWAGE TREATMENT 9

Unit Operations and Processes – Selection of treatment processes — Onsite sanitation – Septic tank- Grey water harvesting- Decentralized sewage treatment – Design of septic tank with depression pit – DEWATS, Intermittent sand filters – Anaerobic filters – Waste stabilization ponds – Design and operation.

UNIT IV SLUDGE STABILIZATION 9

Objectives-Aerobic and Anaerobic Sludge digestion processes – Types of anaerobic digesters – design of Low rate and High rate digesters – Two stage digester-Aerobic digestion- Pure oxygen and thermophilic aerobic digestion - Chemical and Thermal stabilization process

UNIT V REUSE AND LAND APPLICATION OF SEWAGE SLUDGE 9

Introduction- beneficial use-requirements and associated risks-handling and management-storage - operation aspects of transport and application of biosolids application land- Lagooning- Landfilling- land farming-Composting-windrow composting -Vermicomposting -Laws and regulations on sludge management

TOTAL: 45 PERIODS

OUTCOMES:

- CO1** Understand the sanitation value chain with challenges and need for addressing septage
- CO2** Know about desludging and conveyance of septage
- CO3** Plan and implement decentralized sewage treatment scheme
- CO4** Understand technology options for sludge stabilization
- CO5** Know about the requirements and associated risk while reusing sewage sludge

REFERENCES

1. Manual for “Sewerage and Sewage Treatment Systems” CPHEEO, Ministry of Urban Development, Government of India, New Delhi, 2013.
2. Metcalf & Eddy, INC, Wastewater Engineering – Treatment and Reuse, Fourth Edition, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2017.
3. Septage management in urban India, National Urban Sanitation policy, Ministry of Urban Development Government of India, 2013.
4. National Policy on Faecal Sludge and Septage Management (FSSM) Ministry of Urban Development Government of India, 2017
5. A.F. Ismail, Takeshi Matsuura, Membrane Technology for Water and Wastewater Treatment, Energy and Environment, CRC Press, 2016
6. Michael D. Nelson, Chair, Operation of municipal wastewater treatment plants, Water environment federation, vol.2 liquid process.

7. Michael D. Nelson, Chair, Operation of municipal wastewater treatment plants, Water environment federation, vol.1 Management and support systems, sixth edition.
8. Arceivala S.J., and Asolekar S.R "Wastewater Treatment for Pollution Control and reuse "McGraw Hill , third Edition, New Delhi, 2007.

COs- PO's & PSO's MAPPING

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4	2	1	3	2	2	2
5	2	1	2	2	3	2

EV4006

SUSTAINABILITY ENGINEERING

L T P C
3 0 0 3

OBJECTIVES

- To learn about the principles, indicators and general concept of sustainability.
- To apprehend the local, regional and global impacts of unsustainable designs, products and processes.
- To apply the sustainability concepts in engineering.

UNIT I

SUSTAINABILITY

9

Introduction to sustainability concepts, the magnitude of the pressures on resources and ecosystems, Roles of engineers in developing sustainable society, Energy, Materials use, Environmental emissions –ozone depletion, global warming, air quality, water quality, wastes in the India – water, air, solid.

UNIT II

RISK AND LIFE CYCLE BASED FRAME WORKS FOR SUSTAINABILITY

9

Environmental Risk – Risk assessment, Risk based environmental law, Life cycle – Life cycle assessment, Life cycle based environmental law, Life cycle assessment tools, pollution prevention concepts.

UNIT III

SUSTAINABLE MATERIALS

9

Environmental and natural resource use footprints – material extraction and production, material flows in engineered systems, Environmental releases- chemical and physical properties, estimate environmental partitioning, persistence and measures of exposure.

UNIT IV

DESIGN FOR SUSTAINABILITY

9

Sustainable engineering design principles, economic performance indicators, environmental performance indicators, social performance indicators, environmental cost analysis

UNIT V

CASE STUDIES

9

Sustainable built environments, Biofuels for transportation, electric vehicles, bioplastics,

TOTAL: 45 PERIODS

OUTCOMES

1. Students would be able to quantify sustainability, and resource availability.
2. rationalize the sustainability based on scientific merits
3. Understand and apply sustainability concepts in designs, product developments and processes across various engineering disciplines.
4. To make a decision in applying green engineering concepts.
5. Lifelong advocate of sustainability in society.

REFERENCES

1. Sustainable Engineering concepts, design and case studies, David T. Allen and David R. Shonnard, Prentice hall.
2. Engineering applications in sustainable design and development , Bradley Striebig, Adebayao A. Ogundipe and Maria Papadakis, Cengage Learning; 001 edition (January 1, 2015).

COs- PO's & PSO's MAPPING

CO	PO			PSO		
	1	2	3	1	2	3
1	1	2	3	1	3	2
2	1	2	2	2	2	1
3	3	1	3	2	3	1
4	2	1	2	2	3	2
5	1	1	3	2	3	1

EV4007

PROJECT FORMULATION AND IMPLEMENTATION

L T P C
3 0 0 3

OBJECTIVES:

- To examine the techniques and procedures relevant for project planning and implementation in developing countries, especially infrastructure projects pertaining to environmental sector
- To enable the students to understand about project identification, feasibility analysis, design, financing, implementation, monitoring and evaluation

UNIT I INTRODUCTION TO PROJECT FORMULATION

9

Overview of the project cycle – planning process and project planning – search for project ideas – strategies in capital allocation – key elements in project formulation – methods and tools for project formulation – project identification and selection – preparation of feasibility reports as per government policies (AMRUT / JnNURM)

UNIT II PROJECT ANALYSIS

8

Capital cost estimation – market demand analysis – technical analysis – environmental analysis – financial and economic analysis – cash flow generation

UNIT III PROJECT APPRAISAL

10

Time and value of money – investment criteria – internal rate of return – net present value, cost benefit analysis, and social cost benefit analysis – project risk analysis – appraisal of marketing strategy – pricing and credit worthiness and management capabilities

UNIT IV PROJECT FINANCING AND IMPLEMENTATION

10

Funding options for urban and rural development projects – tender procedure – transparency in government tender rules – organizational aspects in project management – network techniques for project management – resource management - risk management

UNIT V PROJECT MONITORING AND EVALUATION

8

Need and techniques for monitoring – service Level benchmark performance and process monitoring – monitoring Schedules – Penalty and Bonus points

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the student is expected to be able to

CO1 Understand the project cycle, key elements in project formulation, methods and tools for project formulation

- CO2** Understand capital cost estimation, market and demand analysis, technical, environmental, financial and economic analysis
- CO3** Understand time and value of money, investment criteria, internal rate of return, cost benefit analysis, project risk analysis and appraisal of marketing strategy
- CO4** Have knowledge on funding options for urban and rural development projects, tender procedure, transparency, resource management & risk management
- CO5** Understand need and techniques for monitoring project performance

REFERENCES:

1. Clifford F Gray, Erik W Larson , “Project Management-The Managerial Process” Tata Mcgraw-Hill Publishing Co Ltd
2. Jack Meredith, Samuel J. Mantel Jr. “Project Management- A Managerial Approach” John Wiley and Sons
3. John M Nicholas “Project Management for Business and Technology” Prentice Hall Of India Pvt Ltd
4. James P Lewis “ Project Planning ,Scheduling And Control” Tata McGraw-Hill.
5. Detailed Project Report: Preparation Toolkit (Sub-mission for Urban Infrastructure and Governance), Government of India
6. www.india.gov.in national portal for India

COs- PO's & PSO's MAPPING

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	1	2	3	1	2	3
1	3	-	2	3	2	2
2	3	1	3	3	1	1
3	1	1	3	3	1	1
4	1	3	3	3	1	1
5	2	-	3	3	2	1

EV4008

ADVANCED OXIDATION PROCESS

**L T P C
3 0 0 3**

OBJECTIVES:

- To identify the most critical issues and challenges that limit the use of conventional treatment processes in planning, design and operation of modern water and wastewater treatment facilities
- To understand the fundamentals of advanced oxidation processes (AOPs), photochemistry, ozone chemistry, and its application to AOPs for the detoxification of contaminated water
- To develop in-depth knowledge that can be used to devise and design effective AOP treatment systems to meet not only current but also anticipated regulatory requirements, and to enhance independent learning and critical thinking skills.

UNIT I INTRODUCTION TO AOPs

8

Introduction to AOPs for water and wastewater treatment – mechanism – photooxidation reactions photocatalytic reactions, photo initiated oxidation – UV- H₂O₂ / ozonation, fenton / photofenton – photocatalysis – light source choice – used in AOPs and their spectral distributions.

UNIT II HOMOGENOUS AOPs

8

Ozone, electro-chemical oxidation, ultrasonication, UV – photolysis, hydrogen peroxide and ultraviolet radiation (H₂O₂ /UV), Fenton and Photo Fenton's oxidation, chemical and non-chemical AOPs, advantages and disadvantages of homogeneous processes.

UNIT III HETEROGENEOUS PROCESS**10**

Introduction to nano & heterogeneous photocatalysis effect of system composition and process. Identification of degradation products, photoreactors (liquid phase/ gas phase) – solar/ artificial light photo reactors – operation of pilot plants – comparing reactor efficiencies – system design – solar collectors – technology issues – slurry, supported catalyst – reuse – novel photocatalysts, synthesis methods – bulk, chemical approaches, physical approaches, nanoporous materials – physic chemical methods for characterization of nanomaterials

UNIT IV AOP ENHANCEMENT TECHNIQUES**9**

Non-thermal plasma-electron hydraulic cavitation and sonolysis- super water oxidation – γ rays-electron beams, Quantum yield improvement by additional oxidants – hydrogen peroxide persulphate– catalyst modification. case studies and applications semiconductor photolysis. process fundamentals, applications and commercial process.

UNIT V INDUSTRIAL APPLICATIONS AND ECONOMIC ASSESSMENT OF AOPs**10**

Application of AOPs for textile, petroleum, pharmaceutical and petrochemical industries - ground water decontamination – drinking water treatment – pilot & land fill photochemical - cost calculation– economic analysis.

TOTAL: 45 PERIODS**OUTCOME:**

On Completion of the course, the student is expected to be able to

- CO1** Comprehend the basic principles of advanced water treatment processes, capabilities / constraints of their application in water and wastewater treatment
- CO2** Apply technical knowledge and skills on the design and operation of AOPs for the water and wastewater treatment
- CO3** Design suitable pre-treatment and post treatment schemes, and cleaning protocols for AOPs
- CO4** Conduct economic assessment on AOTs for water and wastewater treatment
- CO5** Select appropriate AOPs to solve emerging environmental wastewater issues in the society, that are technically sound, economically feasible and socially acceptable

REFERENCES:

1. Cao G., "Nanostructures & Nanomaterials: Synthesis, Properties & Applications", Imperial College Press, 2004.
2. Rose R. M., Shepard L. A. and Wulff J., "The Structure and Properties of Materials", Wiley Eastern Ltd,
3. Simon Parsons, "Advanced oxidation processes for water and wastewater treatment", IWA Publishing, 2004
4. Thomas Oppenländer, "Photochemical Purification of Water and Air: Advanced Oxidation Processes (AOPs): Principles, Reaction Mechanisms, Reactor Concepts", Wiley-VCH Publishing, Published by, 2003
5. Marta.I.Litter, RobertsJ.Candal,J.Martin Meichtry, "Advanced Oxidation Technologies: Sustainable Solution for Environmental Treatment , CRC,Press, 2014.
6. R.M.Rose, L.A.Shepard and J.Wulff, "The Structure and Properties of Materials", Wiley Eastern Ltd, 1996.

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1	1	1	3	3	1	1
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4	1	3	3	1	1	1
5	3	1	3	3	3	3

OBJECTIVES:

- To educate the students to know about the computing techniques used in environmental engineering, and explain the artificial intelligence like ANN, Fuzzy logic and genetic algorithm applications in environmental engineering.

UNIT I SOFT COMPUTING PRINCIPLES 9

Introduction to computing techniques – algorithms and flowcharts, numerical methods - solution to ordinary and partial differential equation using finite difference, finite element and finite volume methods, numerical integration and differentiation.

UNIT II ARTIFICIAL INTELLIGENCE 9

Knowledge based expert system concepts - principle of Artificial Neural Network (ANN) – perceptron learning rule, neural network structure – neural network operations – ANN Algorithm - Application of ANN Model to environmental field – genetic algorithms

UNIT III FUZZY LOGIC 9

Fuzzy logic principles - fuzzy logic and the theory of uncertainty - fuzzy set theory- fuzzy membership function, fuzzy relations, fuzzy rule, and applications of the fuzzy set theory to inference and control, clustering, and image processing.

UNIT IV DIGITAL DATA MANAGEMENT 9

Data base structure - data acquisition - data warehouse - DBMS - RDBMS - data analysis - network data sharing - Statistical Analysis (SYSTAT) - regression - factor analysis - histogram - scatter diagram - goodness of fit – big data analysis.

UNIT V ENVIRONMENTAL MODELING SOFTWARE 9

Introduction to MATLAB Software – MATLAB applications in environmental – pollutants transport, decay and degradation modeling using MIKE 21 – MODFLOW - case studies.

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the students are able to

- CO1 Understand the various computing techniques available for environmental engineering.
 CO2 Apply the principles of ANN and GA for solving environmental problems
 CO3 Apply the principles of Fuzzy logic and for solving environmental problems.
 CO4 Work in the statistical analysis software SYSTAT.
 CO5 Employ modern advanced computing tool MATLAB software in environmental studies

REFERENCES:

- Aliev R. A, and Aliev Rashad, "Soft Computing and its Applications", World Scientific Publications Co. Pte. Ltd. Singapore, 2017.
- Chepra S. C. and Canele R. P., "Numerical Methods for Engineers", McGraw-Hill, a business unit of The McGraw-Hill Companies, Inc., 1221 Avenue of the Americas, New York, NY 10020. 6th Edition 2018.
- Data-Driven Modeling: Using MATLAB in Water Resources and Environmental Engineering, Springer; 2014 edition.
- Mathews J. H. and Fink K.D. "Numerical methods using MATLAB", Pearson Education 2018.

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5	1	2	3	3	1	3

OBJECTIVES

- To acquire the knowledge on the Geotechnical engineering problems associated with soil contamination.
- To safe disposal of waste and remediate the contaminated soils by different techniques
- To remediate the contaminated ground water thereby protecting environment.

UNIT I INTRODUCTION**8**

Emergence of Geo-Environmental engineering, Types of Geo-Environmental problems, inorganic and organic toxic chemicals, composition of soils, soil properties, inorganic and organic geochemistry.

UNIT II CONTAMINANT TRANSPORT AND FATE**10**

Transport processes, chemical mass transfer processes, biological processes, contaminant transport and fate modeling, landfill and surface impoundments, in-situ barriers, ground water contamination

UNIT III SUBSURFACE CONTAMINATION AND WASTE CONTAINMENT**10**

Sources and types of contamination, remediation approach, contaminated site characterization, risk assessment and remedial strategy. Vertical and bottom barriers, surface caps, ground water pumping systems, subsurface drains, liner systems.

UNIT IV SOIL REMEDIATION**8**

Soil vapour extraction, soil washing, stabilization and solidification, electrokinetic remediation, thermal desorption, vitrification, bioremediation, phytoremediation, soil fracturing.

UNIT V GROUND WATER REMEDIATION**9**

Pump and treat, In-situ flushing, permeable reactive barriers, in-situ air sparging monitored natural attenuation, bioremediation.

TOTAL: 45 PERIODS**OUTCOMES**

1. Assess the contamination in the soil
2. Understand the current practice of waste disposal
3. To prepare the suitable disposal system for particular waste.
4. Stabilize the waste and utilization of solid waste for soil improvement.
5. Select suitable remediation methods based on contamination

REFERENCES

1. Sharma H.D. and Reddy K.R., "Geoenvironmental Engineering: Site Remediation, Waste Containment, and Emerging Waste Management Technologies" John Wiley & Sons, Inc., USA, 2004.
2. Yong, R. N., "Geoenvironmental Engineering, Contaminated Soils, Pollutant Fate, and Mitigation" CRC Press, New York, 2001.
3. Reddi L.N. and Inyang, H. I., "Geoenvironmental Engineering, Principles and Applications" Marcel Dekker Inc. New York, 2000.

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3	3	1	2	2	1	1
4	3	1	3	3	2	1
5	2	1	2	3	1	1

OBJECTIVES:

- To educate the students on various instrumental methods of monitoring the quality of air, water and soil.

UNIT I FUNDAMENTALS 9

Wet chemistry methods and their limitations-instrumental methods, selection of method- precision and accuracy, error in measuring signals- quality control & assurance- sample preservation, sample preparation and analyte isolation.

UNIT II SPECTROSCOPIC METHODS 12

Principles, techniques and applications of spectrophotometry, fluorimetry, nephelometry and turbidimetry, Atomic Absorption Spectrometry (Flame, graphite furnace, cold vapour and hydride generation), Atomic Emission Spectrometry (AES), flame photometry and Inducted Coupled Plasma (ICP) – TOC Analyzer

UNIT III CHROMATROGRAPHIC METHODS 8

Principles, techniques and applications of GC, GC-MS, high performance liquid chromatography (HPLC) and Ion Chromatography (IC)-hyphenated techniques for environmental contaminant (trace organics) analysis, ICP-MS

UNIT IV ELECTRO AND RADIO ANALYTICAL METHODS 8

Principles, techniques and applications of conductometry, potentiometry, coulometry, AOX Analyzer. amperometry, polarography, electro-capillary analysis, Neutron Activation Analysis (NAA), X-ray Fluorescence (XRF) and X-ray Diffraction (XRD) methods.

UNIT V CONTINUOUS MONITORING INSTRUMENTS 8

Principles, techniques and applications of NDIR analyzer for CO, chemiluminescent analyzer for NO_x, fluorescent analyzer for SO₂- particulates analysis- auto analyzer for water quality using flow injection analysis. LIMS.

TOTAL: 45 PERIODS**OUTCOMES:**

- CO1: Able to select appropriate instrumental method for chemical analysis
 CO2: Understand spectroscopic methods of analysis of pollutants
 CO3: Select correct method for toxic organics estimation using chromatography methods
 CO4: Understand electro and nondestructive methods of analysis
 CO5: Familiar with online analyzers

REFERENCES:

- Willard H. Merritt, L. Dean, D.A. and Settle, F.A. 'Instrumental methods of analysis Edn. Words Worth, New York, 2004.
- Paul R. Loconto Trace Environmental Quantitative Analysis: Principles, Techniques, and Applications, Marcel Dekker; 2nd Edition , 2005,
- Ewing Instrumental Methods of Chemical Analysis, 5th Edition, McGraw Hill, New York.1985
- Reeve, R.N., "Introduction to Environmental Analysis", Analytical Techniques in the Sciences, John Wiley & Sons, Chichester, UK, 2002.
- Barcelo, D.(editor), "Environmental analysis. Techniques, Applications and Quality Assurance", Elsevier, The Netherlands, 1996

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CO	PO			PSO		
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1	2	1	3	3	1	1
2	2	1	3	2	1	1
3	2	1	2	2	1	1
4	2	1	3	3	2	1
5	3	1	3	3	1	3

OBJECTIVES:

- To understand the fundamentals of mathematical models and their importance in water quality modelling, and to impart the skills to use water quality modelling software for surface and groundwater quality modelling.

UNIT I MODELLING INSIGHTS 9

Engineers and Mathematical models-Water quality models – historical development - different types of models-- steps in model development - importance of model building.- calibration and verification of models- finite element, finite difference and finite volume methods.

UNIT II POLLUTANT TRANSPORT 9

Transport phenomena – advection, diffusion, dispersion- contamination transport in surface and subsurface water - Simple transport models –steady state and time variable solutions- conservation of mass, momentum and energy balance, governing equation for contaminant fate and transport

UNIT III SURFACE WATER QUALITY MODELLING 10

Water quality modeling of streams, lakes and estuaries – water quality– model sensitivity – assessing model performance; Models for dissolved oxygen, pathogens and BOD-Streeter Phelp's model for point and distributed sources - modified streeter Phelp's equations. Tropic status assessment.

UNIT IV GROUNDWATER QUALITY MODELLING 9

Groundwater flow and mass transport of solutes – groundwater quality modelling using numerical methods - degradation of organic compounds in sub surface - prediction of contaminant transport and particle tracking -seawater intrusion – basic concepts and modelling.

UNIT V WATER QUALITY MODELLING SOFTWARE 8

Exposure to surface water and groundwater quality modelling software's – MIKE 21, WASP, QUAL2E and MODFLOW – demonstration - case studies.

TOTAL: 45 PERIODS**OUTCOMES:**

- On completion of the course, the students are able to
- CO1 Know about the principles of water quality modelling.
 CO2 Understand the pollutant transport phenomena in surface and groundwater.
 CO3 Apply the knowledge of surface water quality modelling to predict the water quality of rivers, lakes and estuary.
 CO4 Predict the groundwater contamination transport.
 CO5 Predict water quality of surface and sub surface water using numerical solution.

REFERENCES:

- Steven C. Chapra, "Surface Water Quality Modelling", Tata McGraw-Hill Companies, Inc., New Delhi 2018.
- "Water Quality Modelling for Rivers and Streams" Authors: Benedini, Marcello, Tsakiris, George, Springer Netherlands 2017.
- "Hydrodynamics and Water Quality: Modelling Rivers, Lakes, and Estuaries", Zhen-Gang Ji, John Wiley & Sons, 2018.
- "Modelling Groundwater Flow and Contaminant Transport By Jacob Bear, A. H.-D. Cheng, Springer Science & Business Media, 2010.
- "Mathematical Modelling of Groundwater Pollution" Ne-Zheng Sun, Alexander Sun, Springer New York, 2012

COs- PO's & PSO's MAPPING

CO	PO			PSO		
	1	2	3	1	2	3
1	2	2	3	3	1	1
2	2	2	3	3	1	1
3	3	1	3	3	1	1
4	2	1	3	2	1	1
5	3	3	3	3	1	1

EV4013

MARINE POLLUTION AND CONTROL

L T P C
3 0 0 3

OBJECTIVES:

- To impart the knowledge about marine and coastal environment, oceanography, and sources, effects and monitoring of marine pollutants.

UNIT I MARINE AND COASTAL ENVIRONMENT 9

Seas and oceans, continental area, coastal zone, properties of sea water, principles of marine geology, coastal features – beaches, estuaries, lagoons, salt marshes, mangroves and sand dunes– the oceans and climate, coastal zone regulation in india- national and international treaties.

UNIT II OCEAN HYDRODYNAMICS 9

Wave theory, waves in shallow waters – refraction, diffraction and shoaling, approximations for deep and shallow water conditions – tidal classification - general circulation of ocean waters - ocean currents - coastal sediment transport - onshore offshore sediment transport - beach formation and coastal processes - Tsunamis, storm surge, El Nino effect.

UNIT III MARINE POLLUTION 9

Sources of marine pollution – point and non-point sources, pollution caused by effluent discharge, oil exploration, dredging, offshore mining, port and harbour activities, power plants, agriculture runoff, plastic waste, marine debris and marine litter - effects of marine pollution on marine water quality and coastal ecosystems.

UNIT IV MARINE POLLUTION MONITORING 9

Basic measurements - sounding boat, echo sounders – current meters - tide gauge - use of GPS – measurement of coastal water characteristics – sea bed sampling – modelling of pollutant transport and dispersion - oil spill models - ocean monitoring satellites – applications of remote sensing and GIS in monitoring marine pollution – online marine pollution monitoring,

UNIT V MARINE POLLUTION CONTROL MEASURES 9

Marine discharges and effluent standards, pollution control strategies – marine outfall design- selection of optimal marine outfall locations - Total Maximum Daily Load (TMDL) applications – protocols in marine pollution control– Integrated Coastal Zone Management (ICZM) and sustainable development.

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the students are able to
- CO1 Know about the different components of marine environment.
- CO2 Understand physical concepts lying behind the tides, waves, and oceanic currents and natural processes of various activities happening over the marine environment
- CO3 Identify and measure the marine pollution levels and effects
- CO4 Apply the knowledge of remote sensing and GIS for monitoring marine environment water quality.,
- CO5 Develop marine pollution control measures.

REFERENCES:

1. "Marine Pollution R.B. Clark, C. Frid and M Attrill, Oxford Science Publications, 5th Edition, 2017.
2. Marine Pollution: New Research - Tobias N. Hofer, Nova Publishers, 2018,
3. Laws, E.A., "Aquatic pollution", an introductory text. John Wiley and Sons, Inc., New York, 2000.
4. Practical Handbook of Estuarine and Marine Pollution, Michael J. Kennish, Volume 10 of CRC Marine Science, CRC Press, 1996.

COs- PO's & PSO's MAPPING

CO	PO			PSO		
	1	2	3	1	2	3
1	1	1	2	2	2	2
2	2	1	3	3	2	1
3	2	1	2	3	1	1
4	2	2	2	2	1	2
5	3	2	2	3	1	1

EV4014

CLIMATE CHANGE AND MODELLING

L T P C
3 0 0 3

OBJECTIVES:

- To introduce the emerging concepts of climate modelling and projecting future climate change, understand data analysis and application.

UNIT I CLIMATE CHANGE AND CLIMATE VARIABILITY 9

Introduction- atmosphere - weather and climate - climate parameters (Temperature, Rainfall, Humidity, Wind etc.) Equations governing the atmosphere - numerical weather prediction models - introduction to GCMs - applications in climate change projections

UNIT II IPCC CLIMATE SCENARIOS 9

Intergovernmental PANEL on Climate Change (IPCC) - an overview - key assumptions – Representative Concentration Pathways (RCP 2.6, 4.5, 6.0, 8.5)

UNIT III GLOBAL CLIMATE MODEL AND REGIONAL CLIMATE MODEL 9

Climate model – types of model- General Circulation Models (GCM) - Issues with GCMs - Introduction to RCMs and LAMs - RCMs modellers -advantages and disadvantages of GCMs and RCMs

UNIT IV DOWNSCALING GLOBAL CLIMATE MODEL - AN OVERVIEW 9

Need for downscaling - selection of GCMs for regional climate change studies - ensemble theory selection of ensembles, model domain (Spatial domain and temporal domain), Resolution and climate variables - lateral boundary conditions - methods of downscaling (Statistical and Dynamical) - examples from each and their limitations.

UNIT V ANALYSIS AND POST PROCESSING 9

Model validation and calibration- evaluating model performance- post processing - introduction to analysis tools - Ferret, R, Grads, IDL, SPSS, ArcGIS - climate change impact - vulnerability assessment-case studies-Adaptation strategies

TOTAL: 45 PERIODS

OUTCOMES

- On completion of the course, the student is expected to be able to

CO1: Understand the basics of climate change and variability

CO2: Comprehend the latest IPCC climate scenarios

CO3: Gain in-depth knowledge on climate models

CO4: Downscale of climate scenarios through different modelling techniques, and validate climate models

CO5: Post process the model outputs for climate impact assessment, know about adaptation strategies

UNIT V OPERATION AND MAINTENANCE OF BIOLOGICAL TREATMENT UNITS 9

Construction, operation and maintenance aspects of activated sludge process, trickling filters, anaerobic digester, SBR, UASBR, MBRs- startup and shutdown procedures-DO, MLSS and SVI monitoring- trouble shooting guidelines –planning, organizing and controlling of plant operations – capacity building, case studies of retrofitting- SOP-case studies

TOTAL: 45 PERIODS**OUTCOMES:**

On completion of the course, the student is expected to be able to

- CO1** Understand the O&M issues pertaining to STP and WTP
CO2 Understand operation and maintenance of water intakes and supply systems
CO3 Recognize the O&M issues relevant to sewerage system
CO4 Understand operation and maintenance of physico-chemical treatment units
CO5 Understand operation and maintenance of biological treatment units

REFERENCES:

1. CPHEEO , Manual on operation and maintenance of water supply systems, Central Public Health and Environmental Engineering Organisation, Ministry of Urban Development, Government of India 2013
2. Ministry of Drinking Water and Sanitation, operation and maintenance manual for rural water supplies, Government of India, 2013
3. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017
4. Ananth S Kodavasal, The STP Guide-Design, Operation and maintenance, Karnataka State Pollution Control Board, Bangalore,2011
5. Frik Schutte, handbook for the operation of water Treatment Works,The Water Research Commission, The Water Institute of Southern Africa, TT265/06, 2006.
6. Michael D. Nelson, Chair, Operation of municipal waste water treatment plants, Water environment federation, vol.2 liquid process, 2007.
7. Michael D. Nelson, Chair, Operation of municipal waste water treatment plants, Water environment federation,vol.1 Management and support systems, sixth edition, 2007.

COs- PO's & PSO's MAPPING

CO	PO			PSO		
	1	2	3	1	2	3
1	2	1	2	2	2	1
2	1	2	2	3	2	1
3	2	2	3	3	2	1
4	1	1	3	3	3	1
5	1	1	2	2	2	2

EV4016**AIR QUALITY MODELLING****L T P C
3 0 0 3****OBJECTIVES:**

- To introduce the theory of dispersion of air pollution in the atmosphere and major approaches for air pollution modelling and to demonstrate the features of most widely used commercial and freely available air quality models

UNIT I MODELLING AND MODELS 8

Overview of different types of models-deterministic and stochastic approach- steps in model development- numerical and simulations models- calibration and validation of models- limitations-transport phenomena- mass balance analysis-model development and decision making. Types of air quality models-classification

UNIT II METEOROLOGY AND DISPERSION 11

Chemistry of air Pollutants - atmospheric reactions, sinks for air pollution –transport of air pollutants - meteorological factors for dispersal of air pollutants – meteorological modelling-developing wind

rose and pollutant rose diagrams-vertical structure of temperature and stability, mixing height; tall stacks-transport and diffusion of stack emissions –plume segments–flare stack–plume rise equations-Holland’s and Brigg’s models.

UNIT III EMISSION AND SOURCE DISPERSION MODELS 10

modeling for reactive and nonreactive pollutants, point source-single and multiple sources- area sources, line source models, fixed box models- diffusion models – Gaussian plume derivation-modifications of Gaussian plume equation- Gaussian puff model- emission models-emission factors-long term average-multiple cell model-accuracy and utilization-limitations-air quality mapping

UNIT IV RECEPTOR MODELS AND INDOOR AIR QUALITY MODELS 8

Receptor models- source apportionment studies- CMB model- PMF models; environmental wind tunnel models; indoor air pollutants –mass balance-single compartment-multiple compartments calculation of deposition velocity and Position of Particles-Aerosol-Odours and sick building syndrome-Integrated Models.

UNIT V SOFTWARE PACKAGE APPLICATIONS 8

Commercial air quality models - ADMS, AERMOD, CALINE, CALPUFF, DEGADIS, HYROAD, INDUSTRIAL SOURCE COMPLEX, SCREEN, HYSPLIT, INDEX

TOTAL: 45 PERIODS

OUTCOMES:

- At the end of the course the student will be to
- CO1 Concepts and types of models, model development, their applicability and limitations.
- CO2 Understand the physicochemical transformation of air pollutants in the atmosphere along with the meteorological influence in dispersion of pollutants.
- CO3 Identifies emission source and applies suitable modeling tools to estimate the impact of the pollutants.
- CO4 Fetch knowledge on source inventories, model prediction efficiency and potential risk assessment.
- CO5 Understand the application of models to predicts the air quality scenarios for different conditions and find suitable mitigation measures.

REFERENCES:

1. Noel de Nevers, "Air Pollution Control Engg"., Mc Graw Hill, New York, 2016.
2. Arthur C.Stern, "Air Pollution (Vol.I – Vol.VIII)", Academic Press, 2006.
3. Lawrence K. Wang, Norman C. Parelra, Yung Tse Hung, "Air Pollution Control Engineering", Tokyo, 2004
4. John H. Seinfeld and Spyros N. Pandis Atmospheric Chemistry and Physics: From Air Pollution to Climate Change, 2 nd Edition, , 2006,
5. Mark Z. Jacobson Fundamentals of Atmospheric Modeling, 2 nd Edition, 2005,
6. Deaton and Wine Brake, "Dynamic Modeling of Environmental Systems", Wiley & Sons, 2002.

COs- PO’s & PSO’s MAPPING

CO	PO			PSO		
	1	2	3	1	2	3
1	2	2	3	3	1	1
2	3	2	3	3	1	1
3	3	1	3	3	3	2
4	3	1	2	2	2	2
5	3	1	3	3	2	1

OBJECTIVE:

- To impart knowledge on the priority list of emerging contaminants and improve understanding of their sources, occurrence, distribution, existing regulations/policies, analysis and screening techniques, environmental fate, transport, underlying mechanisms, modelling frameworks, ecotoxicity, risk assessment tools and remediation technologies.

UNIT I SOURCES, OCCURRENCE AND REGULATORY REQUIREMENTS 9

Definition - Priority vs. emerging contaminants - recent concerns - major groups - examples - properties - sources - occurrence - distribution in soils, groundwater, industrial and municipal wastewaters, aquaculture effluents, freshwater and marine ecosystems, air, food, plants, animals and human blood - existing global regulatory frameworks and policies

UNIT II CHARACTERIZATION AND INSTRUMENTATION 7

Sampling – sample preparation methods – analytical protocols for detection of pharmaceuticals, personal care products, antimicrobials and antibiotics, hormones, phthalate plasticizers and degradation products, surfactants, brominated fire retardants, pesticides and nanoparticles – analytical instruments

UNIT III ENVIRONMENTAL FATE AND TRANSPORT 9

Sorption - leaching - runoff - erosion - volatilization - plant/animal uptake - degradation and transformation - human health and ecological risks - environmental fate modelling frameworks - risk assessment tools - challenges - biomonitoring and biosensors

UNIT IV REMEDIATION TECHNOLOGIES 13

Incineration - sonolysis - multi-phase extraction - permeable reactive barrier - advanced oxidation processes - membrane based separation - nanofiltration - Reverse osmosis - biosorption - bioaugmentation - combined treatment options - remediation endpoints - challenges - opportunities

UNIT V CASE STUDIES 7

Occurrence in different environmental compartments - environmental fate and transport - potential and known risks to human health and the environment - effective technological and policy approaches to prevent, control and remove emerging pollutants in the environment

TOTAL: 45 PERIODS**OUTCOMES:**

- On completion of the course, the student is expected to be able to:
- CO1 Explain about the different kinds of emerging contaminants, their sources, occurrence, distribution in different environmental compartments and existing regulations/policies
- CO2 Explain about the analytical techniques for the detection of emerging contaminants in environment
- CO3 Explain about the environmental fate, behaviour, underlying mechanisms, human health and ecological risks of emerging contaminants, and will be able to monitor and assess the degree of environmental contamination by emerging pollutants
- CO4 Select an appropriate single and/or integrated physical, chemical and/or biological clean-up option for environments contaminated with different classes of emerging pollutants in order to achieve the target remedial endpoints
- CO5 Conduct independent research in the future pertinent to emerging contaminant pollution and remediation

REFERENCES:

- Alok Bhandari, Rao Y. Surampalli, Craig D. Adams, Pascale Champagne, Say Kee Ong, R. D. Tyagi and Tian Zhang, Contaminants of Emerging Environmental Concern, American Society of Civil Engineers, US, 2009.
- Caitlin H. Bell, Margaret Gentile, Erica Kalve, Ia Ross, John Horst and Suthan Suthersan, Emerging Contaminants Handbook, CRC Press, US, First edition, 2018.

3. Damia Barcelo and Mira Petrovic, Emerging Contaminants from Industrial and Municipal Waste Removal Technologies, Springer, Germany, 2012.
4. Damia Barcelo, Emerging Organic Contaminants and Human Health, Springer, Germany, 2012.
5. Francisco G, Calvo-Flores, Joaquin Isac-Garcia, Jose A. Dobado, Emerging Pollutants: Origin, Structure and Properties, Wiley & Sons, US, 2018.
6. Giusy Lofrano, Emerging Compounds Removal from Wastewater Natural and Solar Based Treatments, Springer, Germany, 2012

COs- PO's & PSO's MAPPING

CO	PO			PSO		
	1	2	3	1	2	3
1	1	2	3	2	1	1
2	1	2	3	3	1	1
3	2	1	3	3	1	1
4	3	2	3	3	2	1
5	3	1	3	3	1	1

EV4018

ENVIRONMENTAL REACTION ENGINEERING

L T P C
3 0 0 3

OBJECTIVES:

- To gain an understanding of the fundamentals of chemical reaction engineering with a focus on chemical reaction rates and reaction mechanisms. The course will cover mole balances, rate laws, chemical kinetics, and reactor design. These principles can be applied to any environmental system where chemical transformations must be described.

UNIT I PRINCIPLES OF REACTION ENGINEERING 9

Classification of reactions, reaction rate, variables affecting reaction rate, speed of chemical reactions. Reaction engineering principles of chemical treatment – chemical reactions in major treatment technologies, incineration, selective catalytic reduction. Wet- gas scrubbing - H₂S

UNIT II KINETICS OF HOMOGENOUS REACTIONS 9

Simple reactor types, the rate equation, concentration dependent term of rate equation. Molecularity and order of reaction. Rate constant k, representation of an elementary and nonelementary reaction. Kinetic models for nonelementary reactions. Testing kinetic models. Temperature dependent term of rate equations from Arrhenius theory and comparison with collision and transition state theory. Activation energy and temperature dependency.

UNIT III REACTOR ANALYSIS 8

Reactor concepts, ideal reactors, reaction rate measurements, sequencing batch reactor, reactors in series and reactors in recycle. non-ideal reactor behaviour, RTD analysis

UNIT IV MASS TRANSFER AND ITS APPLICATIONS 8

Principles of diffusion and mass transfer between phases, gas absorption, humidification operations, leaching and extraction, drying of solids, fixed-bed separation, membrane separation process-adsorption.

UNIT V BIOLOGICAL REACTION ENGINEERING 10

Kinetics of cell growth and enzymes. cell growth kinetics; substrate uptake and product formation in microbial growth; enzyme kinetics, Michaelis-Menten rate form.-biological kinetics, aerobic processes-anaerobic processes - anaerobic digestion, anaerobic filters, Up flow anaerobic sludge blanket reactor. bio concentration, bioaccumulation, bio magnification, bioassay, bio monitoring. bio scrubbers, bio trickling filters and their applications. vermi technology, methane production, root zone treatment, membrane technology.

TOTAL: 45 PERIODS

OUTCOMES:

- On completion of the course, the student is expected to be able to

- CO1** Successfully apply advanced concepts of reaction engineering to identify, formulate, and solve complex environmental engineering problems
- CO2** Understand interaction of pollutants in environment
- CO3** Understand reactor behavior and transformation of contaminants
- CO4** Conceptualize mass transport phenomena
- CO5** Apply reaction engineering concept in biological treatment system

REFERENCES:

- Weber, W.J and Di Giano, F.A., "Process Dynamics in Environmental systems", John Wiley sons Inc, 1996.
- Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse, Fourth Edition, McGraw-Hill, 2017
- Dunn I.J, Elmar Heinzle, John Ingham, Prenosil J.E, "Biological reaction engineering", Wiley inter science, 2005.
- The Engineering of Chemical reactions by Lanny.D.Schmidt,Oxford University Press , 1997.

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1	3	1	3	3	1	1
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3	3	1	3	3	1	1
4	2	1	3	2	1	1
5	3	1	3	2	2	1

EV4019 MEMBRANE SEPARATION FOR WATER AND WASTEWATER TREATMENT

L T P C
3 0 0 3

OBJECTIVE

- To introduce the principles and design of different membrane separation technologies including microfiltration, ultrafiltration, nanofiltration, reverse osmosis, electrodialysis and membrane bioreactor processes for water and wastewater treatment.

UNIT I MEMBRANE FILTRATION PROCESSES 10

Membrane filtration for solid Liquid separation - cross flow filtration - theory of membrane separation – mass transport characteristics - concentration polarisation – membrane flux and trans membrane pressure -types and choice of membranes- porous, nonporous, symmetric and assymmetric – membrane structures and materials - plate and frame, spiral wound and hollow fibre membranes – membrane performance factors and considerations - membrane manufacturing process.

UNIT II MEMBRANE SYSTEMS 10

Membrane module/element designs – membrane system components – design of membrane systems - design of modules, assembly, plant process control and applications - design and applications of low pressure membrane technology systems-microfiltration and ultrafiltration- design and applications of diffusive membrane technologies- nanofiltration and reverse osmosis - – electro dialysis : Ion exchange membranes, process design- design of membrane systems - pump types and pump selection – plant operations – economics of membrane systems

UNIT III MEMBRANE BIOREACTORS 8

Historical perspective of MBRs- biotreatment fundamentals- MBR principles and fundamentals- MBR design principles, design assignment, alternative MBR configurations - commercial technologies- fouling and fouling control- case studies

UNIT IV PRETREATMENT AND POST TREATMENT SYSTEMS 8

Membrane fouling – source water quality characterization- particulate membrane foulants - mineral membrane-scaling foulants - natural organic foulants- microbial foulants- parameters and measurement methods- Langlier index, silt density index -combined impacts of various types of foulants- control of fouling -pretreatment methods and strategies –source water screening and conditioning- pretreatment by sand and membrane filtration- monitoring of pretreatment –chemical cleaning systems- biofoulant control – post treatment systems

UNIT V CASE STUDIES 9

Case studies on the design of membrane based water and wastewater treatment systems – zero liquid effluent discharge plants – desalination of brackish water and seawater – project implementation and project economics – environmental issues –reject management -energy recovery systems

TOTAL: 45 PERIODS**OUTCOMES:**

- On completion of the course, the student is expected to be able to
- CO1** Explain the various main membrane processes, principles, separation mechanisms, and applications
- CO2** Apply the knowledge of science and engineering fundamentals to analyse the mechanisms of membrane filtration
- CO3** Design of membrane systems involving microfiltration, ultrafiltration, nanofiltration, reverse osmosis, electrodialysis and membrane bioreactor processes
- CO4** Select appropriate membrane technologies for water and wastewater treatment taking into account the impact of the solutions in a sustainability context
- CO5** Conduct research pertinent to membrane technology applications to water and wastewater treatment and communicate effectively to different stakeholders as well as engage in independent life-long learning

REFERENCES:

1. Mihir K. Purkait, Randeep Singh, Membrane Technology in Separation Science, CRC Press, 2018
2. Anthony Wachinski, Membrane Processes for water reuse, McGraw-Hill, Newyork, 2013
3. Nikolay Voutchkov, Desalination Engineering-Planning and Design, McGraw-Hill, Newyork, 2013
4. Symon Jud, MBR Book – "Principles and application of MBR in water and wastewater treatment", Elsevier, 2010.
5. A.F. Ismail, Takeshi Matsuura, Membrane Technology for Water and Wastewater Treatment, Energy and Environment, CRC Press, 2016
6. Kaustubha Mohanty, Mihir K. Purkait, Membrane Technologies and Applications, CRC Press, 2011
7. Baker, R.W., "Membrane technology and applications", 2nd ., John Wiley 2012
8. Metcalf & Eddy, Inc., George Tchobanoglous, Franklin L. Burton and H. David Stensel, Wastewater engineering, treatment and reuse fourth Edition, McGraw-Hill, 2017

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4	3	1	3	3	3	1
5	2	3	2	2	2	3

AUDIT COURSES

AX4091

ENGLISH FOR RESEARCH PAPER WRITING

L T P C
2 0 0 0

OBJECTIVES

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNIT I INTRODUCTION TO RESEARCH PAPER WRITING

6

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

UNIT II PRESENTATION SKILLS

6

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

UNIT III TITLE WRITING SKILLS

6

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS

6

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

UNIT V VERIFICATION SKILLS

6

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

TOTAL: 30 PERIODS

OUTCOMES

CO1 – Understand that how to improve your writing skills and level of readability

CO2 – Learn about what to write in each section

CO3 – Understand the skills needed when writing a Title

CO4 – Understand the skills needed when writing the Conclusion

CO5 – Ensure the good quality of paper at very first-time submission

REFERENCES

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

AX4092

DISASTER MANAGEMENT

L T P C
2 0 0 0

OBJECTIVES

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.

- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION 6
 Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS 6
 Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA 6
 Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT 6
 Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT 6
 Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

TOTAL : 30 PERIODS

OUTCOMES

- CO1: Ability to summarize basics of disaster
- CO2: Ability to explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- CO5: Ability to develop the strengths and weaknesses of disaster management approaches

REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies”,Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. NishithaRai, Singh AK, “Disaster Management in India: Perspectives, issues and strategies “NewRoyal book Company,2007.
3. Sahni, PardeepEt.Al. ,” Disaster Mitigation Experiences And Reflections”, Prentice Hall OfIndia, New Delhi,2001.

**AX4093 CONSTITUTION OF INDIA L T P C
 2 0 0 0**

OBJECTIVES

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals’ constitutional Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION

History, Drafting Committee, (Composition & Working)

UNIT II PHILOSOPHY OF THE INDIAN CONSTITUTION

Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES

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

UNIT IV ORGANS OF GOVERNANCE

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

UNIT V LOCAL ADMINISTRATION

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

UNIT VI ELECTION COMMISSION

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

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- Discuss the passage of the Hindu Code Bill of 1956.

SUGGESTED READING

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

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நற்றமிழ் இலக்கியம்

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UNIT I

சங்க இலக்கியம்

6

1. தமிழின் துவக்க நூல் தொல்காப்பியம்
- எழுத்து, சொல், பொருள்
2. அகநானூறு (82)
- இயற்கை இன்னிசை அரங்கம்
3. குறிஞ்சிப் பாட்டின் மலர்க்காட்சி
4. புறநானூறு (95,195)
- போரை நிறுத்திய ஓளவையார்

UNIT II	அறநெறித் தமிழ்	6
	1. அறநெறி வகுத்த திருவள்ளுவர் - அறம் வலியுறுத்தல், அன்புடைமை, ஒப்புரவறிதல், ஈகை, புகழ்	
	2. பிற அறநூல்கள் - இலக்கிய மருந்து - ஏலாதி, சிறுபஞ்சமூலம், திரிகடுகம், ஆசாரக்கோவை (தூய்மையை வலியுறுத்தும் நூல்)	
UNIT III	இரட்டைக் காப்பியங்கள்	6
	1. கண்ணகியின் புரட்சி - சிலப்பதிகார வழக்குரை காதை சமூகசேவை இலக்கியம் மணிமேகலை - சிறைக்கோட்டம் அறக்கோட்டமாகிய காதை	
UNIT IV	அருள்நெறித் தமிழ்	6
	1. சிறுபாணாற்றுப்படை - பாரி முல்லைக்குத் தேர் கொடுத்தது, பேகன் மயிலுக்குப் போர்வை கொடுத்தது, அதியமான் ஓளவைக்கு நெல்லிக்கனி கொடுத்தது, அரசர் பண்புகள்	
	2. நற்றிணை - அன்னைக்குரிய புன்னை சிறப்பு	
	3. திருமந்திரம் (617, 618) - இயமம் நியமம் விதிகள்	
	4. தர்மச்சாலையை நிறுவிய வள்ளலார்	
	5. புறநானூறு - சிறுவனே வள்ளலானான்	
	6. அகநானூறு (4) - வண்டு நற்றிணை (11) - நண்டு கலித்தொகை (11) - யானை, புறா ஐந்திணை 50 (27) - மான் ஆகியவை பற்றிய செய்திகள்	
UNIT V	நவீன தமிழ் இலக்கியம்	6
	1. உரைநடைத் தமிழ், - தமிழின் முதல் புதினம், - தமிழின் முதல் சிறுகதை, - கட்டுரை இலக்கியம், - பயண இலக்கியம், - நாடகம்.	
	2. நாட்டு விடுதலை போராட்டமும் தமிழ் இலக்கியமும்,	
	3. சமுதாய விடுதலையும் தமிழ் இலக்கியமும்,	
	4. பெண் விடுதலையும் விளிம்பு நிலையினரின் மேம்பாட்டில் தமிழ் இலக்கியமும்,	
	5. அறிவியல் தமிழ்,	
	6. இணையத்தில் தமிழ்,	
	7. சுற்றுச்சூழல் மேம்பாட்டில் தமிழ் இலக்கியம்.	

TOTAL: 30 PERIODS

தமிழ் இலக்கிய வெளியீடுகள் / புத்தகங்கள்

1. தமிழ் இணைய கல்விக்கழகம் (Tamil Virtual University) - www.tamilvu.org
2. தமிழ் விக்கிப்பீடியா (Tamil Wikipedia) - <https://ta.wikipedia.org>
3. தர்மபுர ஆதீன வெளியீடு
4. வாழ்வியல் களஞ்சியம் - தமிழ்ப் பல்கலைக்கழகம், தஞ்சாவூர்
5. தமிழ்கலைக் களஞ்சியம் - தமிழ் வளர்ச்சித் துறை (thamilvalarchithurai.com)
6. அறிவியல் களஞ்சியம் - தமிழ்ப் பல்கலைக்கழகம், தஞ்சாவூர்



OPEN ELECTIVES

OIC431

BLOCKCHAIN TECHNOLOGIES

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COURSE OBJECTIVES:

- This course is intended to study the basics of Blockchain technology.
- During this course the learner will explore various aspects of Blockchain technology like application in various domains.
- By implementing, learners will have idea about private and public Blockchain, and smart contract.

UNIT I INTRODUCTION OF CRYPTOGRAPHY AND BLOCKCHAIN 9

Introduction to Blockchain, Blockchain Technology Mechanisms & Networks, Blockchain Origins, Objective of Blockchain, Blockchain Challenges, Transactions and Blocks, P2P Systems, Keys as Identity, Digital Signatures, Hashing, and public key cryptosystems, private vs. public Blockchain.

UNIT II BITCOIN AND CRYPTOCURRENCY 9

Introduction to Bitcoin, The Bitcoin Network, The Bitcoin Mining Process, Mining Developments, Bitcoin Wallets, Decentralization and Hard Forks, Ethereum Virtual Machine (EVM), Merkle Tree, Double-Spend Problem, Blockchain and Digital Currency, Transactional Blocks, Impact of Blockchain Technology on Cryptocurrency.

UNIT III INTRODUCTION TO ETHEREUM 9

Introduction to Ethereum, Consensus Mechanisms, Metamask Setup, Ethereum Accounts,, Transactions, Receiving Ethers, Smart Contracts.

UNIT IV INTRODUCTION TO HYPERLEDGER AND SOLIDITY PROGRAMMING 10

Introduction to Hyperledger, Distributed Ledger Technology & its Challenges, Hyperledger & Distributed Ledger Technology, Hyperledger Fabric, Hyperledger Composer. Solidity - Language of Smart Contracts, Installing Solidity & Ethereum Wallet, Basics of Solidity, Layout of a Solidity Source File & Structure of Smart Contracts, General Value Types.

UNIT V BLOCKCHAIN APPLICATIONS 8

Internet of Things, Medical Record Management System, Domain Name Service and Future of Blockchain, Alt Coins.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

After the completion of this course, student will be able to

CO1: Understand and explore the working of Blockchain technology

CO2: Analyze the working of Smart Contracts

CO3: Understand and analyze the working of Hyperledger

CO4: Apply the learning of solidity to build de-centralized apps on Ethereum

CO5: Develop applications on Blockchain

REFERENCES:

1. Imran Bashir, "Mastering Blockchain: Distributed Ledger Technology, Decentralization, and Smart Contracts Explained", Second Edition, Packt Publishing, 2018.
2. Narayanan, J. Bonneau, E. Felten, A. Miller, S. Goldfeder, "Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction" Princeton University Press, 2016
3. Antonopoulos, Mastering Bitcoin, O'Reilly Publishing, 2014. .
4. Antonopoulos and G. Wood, "Mastering Ethereum: Building Smart Contracts and Dapps", O'Reilly Publishing, 2018.
5. D. Drescher, Blockchain Basics. Apress, 2017.

COURSE OBJECTIVES:

- Develop and Train Deep Neural Networks.
- Develop a CNN, R-CNN, Fast R-CNN, Faster-R-CNN, Mask-RCNN for detection and recognition
- Build and train RNNs, work with NLP and Word Embeddings
- The internal structure of LSTM and GRU and the differences between them
- The Auto Encoders for Image Processing

UNIT I DEEP LEARNING CONCEPTS**6**

Fundamentals about Deep Learning. Perception Learning Algorithms. Probabilistic modelling. Early Neural Networks. How Deep Learning different from Machine Learning. Scalars. Vectors. Matrixes, Higher Dimensional Tensors. Manipulating Tensors. Vector Data. Time Series Data. Image Data. Video Data.

UNIT II NEURAL NETWORKS**9**

About Neural Network. Building Blocks of Neural Network. Optimizers. Activation Functions. Loss Functions. Data Pre-processing for neural networks, Feature Engineering. Overfitting and Underfitting. Hyperparameters.

UNIT III CONVOLUTIONAL NEURAL NETWORK**10**

About CNN. Linear Time Invariant. Image Processing Filtering. Building a convolutional neural network. Input Layers, Convolution Layers. Pooling Layers. Dense Layers. Backpropagation Through the Convolutional Layer. Filters and Feature Maps. Backpropagation Through the Pooling Layers. Dropout Layers and Regularization. Batch Normalization. Various Activation Functions. Various Optimizers. LeNet, AlexNet, VGG16, ResNet. Transfer Learning with Image Data. Transfer Learning using Inception Oxford VGG Model, Google Inception Model, Microsoft ResNet Model. R-CNN, Fast R-CNN, Faster R-CNN, Mask-RCNN, YOLO

UNIT IV NATURAL LANGUAGE PROCESSING USING RNN**10**

About NLP & its Toolkits. Language Modeling . Vector Space Model (VSM). Continuous Bag of Words (CBOW). Skip-Gram Model for Word Embedding. Part of Speech (PoS) Global Co-occurrence Statistics-based Word Vectors. Transfer Learning. Word2Vec. Global Vectors for Word Representation GloVe. Backpropagation Through Time. Bidirectional RNNs (BRNN) . Long Short Term Memory (LSTM). Bi-directional LSTM. Sequence-to-Sequence Models (Seq2Seq). Gated recurrent unit GRU.

UNIT V DEEP REINFORCEMENT & UNSUPERVISED LEARNING**10**

About Deep Reinforcement Learning. Q-Learning. Deep Q-Network (DQN). Policy Gradient Methods. Actor-Critic Algorithm. About Autoencoding. Convolutional Auto Encoding. Variational Auto Encoding. Generative Adversarial Networks. Autoencoders for Feature Extraction. Auto Encoders for Classification. Denoising Autoencoders. Sparse Autoencoders

TOTAL : 45 PERIODS**COURSE OUTCOMES:****CO1:** Feature Extraction from Image and Video Data**CO2:** Implement Image Segmentation and Instance Segmentation in Images**CO3:** Implement image recognition and image classification using a pretrained network (Transfer Learning)**CO4:** Traffic Information analysis using Twitter Data**CO5:** Autoencoder for Classification & Feature Extraction**REFERENCES**

1. Deep Learning A Practitioner's Approach Josh Patterson and Adam Gibson O'Reilly Media, Inc.2017
2. Learn Keras for Deep Neural Networks, Jojo Moolayil, Apress,2018
3. Deep Learning Projects Using TensorFlow 2, Vinita Silaparasetty, Apress, 2020

4. Deep Learning with Python, FRANÇOIS CHOLLET, MANNING SHELTER ISLAND, 2017
5. Pro Deep Learning with TensorFlow, Santanu Pattanayak, Apress, 2017

OME431 VIBRATION AND NOISE CONTROL STRATEGIES

L T P C
3 0 0 3

OBJECTIVES

- To appreciate the basic concepts of vibration in damped and undamped systems
- To appreciate the basic concepts of noise, its effect on hearing and related terminology
- To use the instruments for measuring and analyzing the vibration levels in a body
- To use the instruments for measuring and analyzing the noise levels in a system
- To learn the standards of vibration and noise levels and their control techniques

UNIT I BASICS OF VIBRATION

9

Introduction – Sources and causes of Vibration-Mathematical Models - Displacement, velocity and Acceleration - Classification of vibration: free and forced vibration, undamped and damped vibration, linear and non-linear vibration - Single Degree Freedom Systems - Vibration isolation - Determination of natural frequencies

UNIT II BASICS OF NOISE

9

Introduction - Anatomy of human ear - Mechanism of hearing - Amplitude, frequency, wavelength and sound pressure level - Relationship between sound power, sound intensity and sound pressure level - Addition, subtraction and averaging decibel levels - sound spectra -Types of sound fields - Octave band analysis - Loudness.

UNIT III INSTRUMENTATION FOR VIBRATION MEASUREMENT

9

Experimental Methods in Vibration Analysis.- Vibration Measuring Instruments - Selection of Sensors - Accelerometer Mountings - Vibration Exciters - Mechanical, Hydraulic, Electromagnetic and Electrodynamics – Frequency Measuring Instruments -. System Identification from Frequency Response -Testing for resonance and mode shapes

UNIT IV INSTRUMENTATION FOR NOISE MEASUREMENT AND ANALYSIS

9

Microphones - Weighting networks - Sound Level meters, its classes and calibration - Noise measurements using sound level meters - Data Loggers - Sound exposure meters - Recording of noise - Spectrum analyser - Intensity meters - Energy density sensors - Sound source localization.

UNIT V METHODS OF VIBRATION CONTROL, SOURCES OF NOISE AND ITS CONTROL

9

Specification of Vibration Limits – Vibration severity standards - Vibration as condition Monitoring Tool – Case Studies - Vibration Isolation methods - Dynamic Vibration Absorber – Need for Balancing - Static and Dynamic Balancing machines – Field balancing - Major sources of noise - Noise survey techniques – Measurement technique for vehicular noise - Road vehicles Noise standard – Noise due to construction equipment and domestic appliances – Industrial noise sources and its strategies – Noise control at the source – Noise control along the path – Acoustic Barriers – Noise control at the receiver -- Sound transmission through barriers – Noise reduction Vs Transmission loss - Enclosures

TOTAL: 45 PERIODS

OUTCOMES:

On Completion of the course the student will be able to

1. apply the basic concepts of vibration in damped and undamped systems
2. apply the basic concepts of noise and to understand its effects on systems
3. select the instruments required for vibration measurement and its analysis
4. select the instruments required for noise measurement and its analysis.
5. recognize the noise sources and to control the vibration levels in a body and to control noise under different strategies.

REFERENCES:

1. Singiresu S. Rao, "Mechanical Vibrations", Pearson Education Incorporated, 2017.
2. Graham Kelly. Sand Shashidhar K. Kudari, "Mechanical Vibrations", Tata McGraw –Hill Publishing Com. Ltd., 2007.
3. Ramamurti. V, "Mechanical Vibration Practice with Basic Theory", Narosa Publishing House, 2000.
4. William T. Thomson, "Theory of Vibration with Applications", Taylor & Francis, 2003.
5. G.K. Grover, "Mechanical Vibrations", Nem Chand and Bros.,Roorkee, 2014.
6. A.G. Ambekar, "Mechanical Vibrations and Noise Engineering", PHI Learning Pvt. Ltd., 2014.
7. David A. Bies and Colin H. Hansen, "Engineering Noise Control – Theory and Practice", Spon Press, London and New York, 2009.

OME432 ENERGY CONSERVATION AND MANAGEMENT IN DOMESTIC SECTORS

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COURSE OBJECTIVES:

- To learn the present energy scenario and the need for energy conservation.
- To understand the different measures for energy conservation in utilities.
- Acquaint students with principle theories, materials, and construction techniques to create energy efficient buildings.
- To identify the energy demand and bridge the gap with suitable technology for sustainable habitat
- To get familiar with the energy technology, current status of research and find the ways to optimize a system as per the user requirement

UNIT I ENERGY SCENARIO 9

Primary energy resources - Sectorial energy consumption (domestic, industrial and other sectors), Energy pricing, Energy conservation and its importance, Energy Conservation Act-2001 and its features – Energy star rating.

UNIT II HEATING, VENTILLATION & AIR CONDITIONING 9

Basics of Refrigeration and Air Conditioning – COP / EER / SEC Evaluation – SPV system design & optimization for Solar Refrigeration.

UNIT III LIGHTING, COMPUTER, TV 9

Specification of Luminaries – Types – Efficacy – Selection & Application – Time Sensors – Occupancy Sensors – Energy conservation measures in computer – Television – Electronic devices.

UNIT IV ENERGY EFFICIENT BUILDINGS 9

Conventional versus Energy efficient buildings – Landscape design – Envelope heat loss and heat gain – Passive cooling and heating – Renewable sources integration.

UNIT V ENERGY STORAGE TECHNOLOGIES 9

Necessity & types of energy storage – Thermal energy storage – Battery energy storage, charging and discharging– Hydrogen energy storage & Super capacitors – energy density and safety issues – Applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

1. Understand technical aspects of energy conservation scenario.
2. Energy audit in any type for domestic buildings and suggest the conservation measures.
3. Perform building load estimates and design the energy efficient landscape system.
4. Gain knowledge to utilize an appliance/device sustainably.
5. Understand the status and current technological advancement in energy storage field.

REFERENCES:

1. Yogi Goswami, Frank Kreith, Energy Efficiency and Renewable energy Handbook, CRC Press, 2016
2. ASHRAE Handbook 2020 – HVAC Systems & Equipment
3. Paolo Bertoldi, Andrea Ricci, Anibal de Almeida, Energy Efficiency in Household Appliances and Lighting, Conference proceedings, Springer, 2001
4. David A. Bainbridge, Ken Haggard, Kenneth L. Haggard, Passive Solar Architecture: Heating, Cooling, Ventilation, Daylighting, and More Using Natural Flows, Chelsea Green Publishing, 2011.
5. Guide book for National Certification Examination for Energy Managers and Energy Auditors (Could be downloaded from www.energymanagertraining.com)
6. Ibrahim Dincer and Mark A. Rosen, Thermal Energy Storage Systems and Applications, John Wiley & Sons 2002.
7. Robert Huggins, Energy Storage: Fundamentals, Materials and Applications, 2nd edition, Springer, 2015
8. Ru-shiliu, Leizhang, Xueliang sun, Electrochemical technologies for energy storage and conversion, Wiley publications, 2012.

OME433

ADDITIVE MANUFACTURING

L T P C
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UNIT I INTRODUCTION

9

Need - Development - Rapid Prototyping Rapid Tooling – Rapid Manufacturing – Additive Manufacturing. AM Process Chain- Classification – Benefits.

UNIT II DESIGN FOR ADDITIVE MANUFACTURING

9

CAD Model Preparation - Part Orientation and Support Structure Generation -Model Slicing - Tool Path Generation Customized Design and Fabrication - Case Studies.

UNIT III VAT POLYMERIZATION

9

Stereolithography Apparatus (SLA)- Materials -Process -Advantages Limitations- Applications. Digital Light Processing (DLP) - Materials – Process - Advantages - Applications. Multi Jet Modelling (MJM) - Principles - Process - Materials - Advantages and Limitations.

UNIT IV MATERIAL EXTRUSION AND SHEET LAMINATION

9

Fused Deposition Modeling (FDM)- Process-Materials - Applications and Limitations. Sheet Lamination Process: Laminated Object Manufacturing (LOM)- Basic Principle- Mechanism: Gluing or Adhesive Bonding – Thermal Bonding- Materials- Application and Limitation - Bio-Additive Manufacturing Computer Aided Tissue Engineering (CATE) – Case studies

POWDER BASED PROCESS

Selective Laser Sintering (SLS): Process –Mechanism– Typical Materials and Application- Multi Jet Fusion - Basic Principle– Materials- Application and Limitation - Three Dimensional Printing - Materials -Process - Benefits and Limitations. Selective Laser Melting (SLM) and Electron Beam Melting (EBM): Materials – Process - Advantages and Applications. Beam Deposition Process: Laser Engineered Net Shaping (LENS)- Process -Material Delivery - Process Parameters -Materials - Benefits -Applications.

UNIT V CASE STUDIES AND OPPORTUNITIES ADDITIVE MANUFACTURING PROCESSES

9

Education and training - Automobile- pattern and mould - tooling - Building Printing-Bio Printing - medical implants -development of surgical tools Food Printing -Printing Electronics. Business Opportunities and Future Directions - Intellectual Property.

TOTAL: 45 PERIODS

REFERENCES:

1. Andreas Gebhardt and Jan-Steffen Hötter “Additive Manufacturing: 3D Printing for Prototyping and Manufacturing”, Hanser publications, United States, 2015, ISBN: 978-1- 56990-582-1.
2. Ian Gibson, David W. Rosen and Brent Stucker “Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing”, 2nd edition, Springer., United States, 2015, ISBN13: 978-1493921126.
3. Amit Bandyopadhyay and Susmita Bose, “Additive Manufacturing”, 1st Edition, CRC Press., United States, 2015, ISBN-13: 978-1482223590
4. Andreas Gebhardt, “Understanding Additive Manufacturing: Rapid Prototyping, Rapid Manufacturing”, Hanser Gardner Publication, Cincinnati., Ohio, 2011, ISBN :9783446425521.
5. Chua C.K., Leong K.F., and Lim C.S., “Rapid prototyping: Principles and applications”, Third edition, World Scientific Publishers, 2010.

OME434

ELECTRIC VEHICLE TECHNOLOGY

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UNIT I NEED FOR ELECTRIC VEHICLES

9

History and need for electric and hybrid vehicles, social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies, comparison of diesel, petrol, electric and hybrid vehicles, limitations, technical challenges

UNIT II ELECTRIC VEHICLE ARCHITECTURE

9

Electric vehicle types, layout and power delivery, performance – traction motor characteristics, tractive effort, transmission requirements, vehicle performance, energy consumption, Concepts of hybrid electric drive train, architecture of series and parallel hybrid electric drive train, merits and demerits, mild and full hybrids, plug-in hybrid electric vehicles and range extended hybrid electric vehicles, Fuel cell vehicles.

UNIT III ENERGY STORAGE

9

Batteries – types – lead acid batteries, nickel based batteries, and lithium based batteries, electrochemical reactions, thermodynamic voltage, specific energy, specific power, energy efficiency, Battery modeling and equivalent circuit, battery charging and types, battery cooling, Ultra-capacitors, Flywheel technology, Hydrogen fuel cell, Thermal Management of the PEM fuel cell

UNIT IV ELECTRIC DRIVES AND CONTROL

9

Types of electric motors – working principle of AC and DC motors, advantages and limitations, DC motor drives and control, Induction motor drives and control, PMSM and brushless DC motor -drives and control , AC and Switch reluctance motor drives and control – Drive system efficiency – Inverters – DC and AC motor speed controllers

UNIT V DESIGN OF ELECTRIC VEHICLES

9

Materials and types of production, Chassis skate board design, motor sizing, power pack sizing, component matching, Ideal gear box – Gear ratio, torque–speed characteristics, Dynamic equation of vehicle motion, Maximum tractive effort – Power train tractive effort Acceleration performance, rated vehicle velocity – maximum gradability, Brake performance, Electronic control system, safety and challenges in electric vehicles. Case study of Nissan leaf, Toyota Prius, tesla model 3, and Renault Zoe cars.

TOTAL: 45 PERIODS

REFERENCES:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, 2nd edition CRC Press, 2011.
2. Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
3. James Larminie, John Lowry, Electric Vehicle Technology Explained - Wiley, 2003.
4. Ehsani, M, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC Press, 2005

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for:

1. Applying the principles of generic development process; and understanding the organization structure for new product design and development.
2. Identifying opportunity and planning for new product design and development.
3. Conducting customer need analysis; and setting product specification for new product design and development.
4. Generating, selecting, and testing the concepts for new product design and development.
5. Applying the principles of Industrial design and prototype for new product design and development.

UNIT I INTRODUCTION TO PRODUCT DESIGN & DEVELOPMENT 9

Introduction – Characteristics of Successful Product Development – People involved in Product Design and Development – Duration and Cost of Product Development – The Challenges of Product Development – The Product Development Process – Concept Development: The Front-End Process – Adapting the Generic Product Development Process – Product Development Process Flows – Product Development Organizations.

UNIT II OPPORTUNITY IDENTIFICATION & PRODUCT PLANNING 9

Opportunity Identification: Definition – Types of Opportunities – Tournament Structure of Opportunity Identification – Effective Opportunity Tournaments – Opportunity Identification Process – Product Planning: Four types of Product Development Projects – The Process of Product Planning.

UNIT III IDENTIFYING CUSTOMER NEEDS & PRODUCT SPECIFICATIONS 9

Identifying Customer Needs: The Importance of Latent Needs – The Process of Identifying Customer Needs. Product Specifications: Definition – Time of Specifications Establishment – Establishing Target Specifications – Setting the Final Specifications

UNIT IV CONCEPT GENERATION, SELECTION & TESTING 9

Concept Generation: Activity of Concept Generation – Structured Approach – Five step method of Concept Generation. Concept Selection: Methodology – Concept Screening and Concepts Scoring. Concept testing: Seven Step activities of concept testing.

UNIT V INDUSTRIAL DESIGN & PROTOTYPING 9

Industrial Design: Need and Impact–Industrial Design Process. Prototyping – Principles of Prototyping – Prototyping Technologies – Planning for Prototypes.

TOTAL: 45 PERIODS**COURSE OUTCOMES:**

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

1. Apply the principles of generic development process; and understand the organization structure for new product design and development.
2. Identify opportunity and plan for new product design and development.
3. Conduct customer need analysis; and set product specification for new product design and development.
4. Generate, select, and test the concepts for new product design and development.
5. Apply the principles of Industrial design and prototype for design and develop new products.

TEXT BOOK:

1. Ulrich K.T., Eppinger S. D. and Anita Goyal, "Product Design and Development "McGraw-Hill Education; 7 edition, 2020.

REFERENCES:

1. Belz A., 36-Hour Course: "Product Development" McGraw-Hill, 2010.
2. Rosenthal S., "Effective Product Design and Development", Business One Orwin, Homewood, 1992, ISBN1-55623-603-4.
3. Pugh.S, "Total Design Integrated Methods for Successful Product Engineering", Addison Wesley Publishing, 1991, ISBN0-202-41639-5.
4. Chitale, A. K. and Gupta, R. C., Product Design and Manufacturing, PHI Learning, 2013.
5. Jamnia, A., Introduction to Product Design and Development for Engineers, CRC Press, 2018.

OBA431

SUSTAINABLE MANAGEMENT

LT P C
3 0 0 3

COURSE OBJECTIVES:

- To provide students with fundamental knowledge of the notion of corporate sustainability.
- To determine how organizations impacts on the environment and socio-technical systems, the relationship between social and environmental performance and competitiveness, the approaches and methods.

UNIT I MANAGEMENT OF SUSTAINABILITY 9

Management of sustainability -rationale and political trends: An introduction to sustainability management, International and European policies on sustainable development, theoretical pillars in sustainability management studies.

UNIT II CORPORATE SUSTAINABILITY AND RESPONSIBILITY 9

Corporate sustainability parameter, corporate sustainability institutional framework, integration of sustainability into strategic planning and regular business practices, fundamentals of stakeholder engagement.

UNIT III SUSTAINABILITY MANAGEMENT: STRATEGIES AND APPROACHES 9

Corporate sustainability management and competitiveness: Sustainability-oriented corporate strategies, markets and competitiveness, Green Management between theory and practice, Sustainable Consumption and Green Marketing strategies, Environmental regulation and strategic postures; Green Management approaches and tools; Green engineering: clean technologies and innovation processes; Sustainable Supply Chain Management and Procurement.

UNIT IV SUSTAINABILITY AND INNOVATION 9

Socio-technical transitions and sustainability, Sustainable entrepreneurship, Sustainable pioneers in green market niches, Smart communities and smart specializations.

UNIT V SUSTAINABLE MANAGEMENT OF RESOURCES, COMMODITIES AND COMMONS 9

Energy management, Water management, Waste management, Wild Life Conservation, Emerging trends in sustainable management, Case Studies.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- CO1:** An understanding of sustainability management as an approach to aid in evaluating and minimizing environmental impacts while achieving the expected social impact.
- CO2:** An understanding of corporate sustainability and responsible Business Practices
- CO3:** Knowledge and skills to understand, to measure and interpret sustainability performances.
- CO4:** Knowledge of innovative practices in sustainable business and community management
- CO5:** Deep understanding of sustainable management of resources and commodities

REFERENCES:

1. Daddi, T., Iraldo, F., Testa, Environmental Certification for Organizations and Products: Management, 2015
2. Christian N. Madu, Handbook of Sustainability Management 2012
3. Petra Molthan-Hill, The Business Student's Guide to Sustainable Management: Principles and Practice, 2014
4. Margaret Robertson, Sustainability Principles and Practice, 2014
5. Peter Rogers, An Introduction to Sustainable Development, 2006

OBA432

MICRO AND SMALL BUSINESS MANAGEMENT

L T P C
3 0 0 3

COURSE OBJECTIVES

- To familiarize students with the theory and practice of small business management.
- To learn the legal issues faced by small business and how they impact operations.

UNIT I INTRODUCTION TO SMALL BUSINESS 9

Creation, Innovation, entrepreneurship and small business - Defining Small Business –Role of Owner – Manager – government policy towards small business sector –elements of entrepreneurship –evolution of entrepreneurship –Types of Entrepreneurship – social, civic, corporate - Business life cycle - barriers and triggers to new venture creation – process to assist start ups – small business and family business.

UNIT II SCREENING THE BUSINESS OPPORTUNITY AND FORMULATING THE BUSINESS PLAN 9

Concepts of opportunity recognition; Key factors leading to new venture failure; New venture screening process; Applying new venture screening process to the early stage small firm Role planning in small business – importance of strategy formulation – management skills for small business creation and development.

UNIT III BUILDING THE RIGHT TEAM AND MARKETING STRATEGY 9

Management and Leadership – employee assessments – Tuckman's stages of group development - The entrepreneurial process model - Delegation and team building - Comparison of HR management in small and large firms - Importance of coaching and how to apply a coaching model. Marketing within the small business - success strategies for small business marketing - customer delight and business generating systems, - market research, - assessing market performance- sales management and strategy - the marketing mix and marketing strategy.

UNIT IV FINANCING SMALL BUSINESS 9

Main sources of entrepreneurial capital; Nature of 'bootstrap' financing - Difference between cash and profit - Nature of bank financing and equity financing - Funding-equity gap for small firms. Importance of working capital cycle - Calculation of break-even point - Power of gross profit margin- Pricing for profit - Credit policy issues and relating these to cash flow management and profitability.

UNIT V VALUING SMALL BUSINESS AND CRISIS MANAGEMENT 9

Causes of small business failure - Danger signals of impending trouble - Characteristics of poorly performing firms - Turnaround strategies - Concept of business valuation - Different valuation measurements - Nature of goodwill and how to measure it - Advantages and disadvantages of buying an established small firm - Process of preparing a business for sale.

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1. Familiarise the students with the concept of small business

CO2. In depth knowledge on small business opportunities and challenges

CO3. Ability to devise plans for small business by building the right skills and marketing strategies

CO4. Identify the funding source for small start ups

CO5. Business evaluation for buying and selling of small firms

REFERENCES

1. Hankinson,A.(2000). "The key factors in the profile of small firm owner-managers that influence business performance. The South Coast Small Firms Survey, 1997-2000." Industrial and Commercial Training 32(3):94-98.
2. Parker,R.(2000). "Small is not necessarily beautiful: An evaluation of policy support for small and medium-sized enterprise in Australia." Australian Journal of Political Science 35(2):239-253.
3. Journal articles on SME's.

OBA433

INTELLECTUAL PROPERTY RIGHTS

L T P C
3 0 0 3

COURSE OBJECTIVE

- To understand intellectual property rights and its valuation.

UNIT I INTRODUCTION

9

Intellectual property rights - Introduction, Basic concepts, Patents, Copyrights, Trademarks, Trade Secrets, Geographic Indicators; Nature of Intellectual Property, Technological Research, Inventions and Innovations, History - the way from WTO to WIPO, TRIPS.

UNIT II PROCESS

9

New Developments in IPR, Procedure for grant of Patents, TM, GIs, Patenting under Patent Cooperation Treaty, Administration of Patent system in India, Patenting in foreign countries.

UNIT III STATUTES

9

International Treaties and conventions on IPRs, The TRIPs Agreement, PCT Agreement, The Patent Act of India, Patent Amendment Act (2005), Design Act, Trademark Act, Geographical Indication Act, Bayh- Dole Act and Issues of Academic Entrepreneurship.

UNIT IV STRATEGIES IN INTELLECTUAL PROPERTY

9

Strategies for investing in R&D, Patent Information and databases, IPR strength in India, Traditional Knowledge, Case studies.

UNIT V MODELS

9

The technologies Know-how, concept of ownership, Significance of IP in Value Creation, IP Valuation and IP Valuation Models, Application of Real Option Model in Strategic Decision Making, Transfer and Licensing.

TOTAL: 45 PERIODS

COURSE OUTCOMES

CO1: Understanding of intellectual property and appreciation of the need to protect it

CO2: Awareness about the process of patenting

CO3: Understanding of the statutes related to IPR

CO4: Ability to apply strategies to protect intellectual property

CO5: Ability to apply models for making strategic decisions related to IPR

REFERENCES

1. V. Sople Vinod, Managing Intellectual Property by (Prentice hall of India Pvt.Ltd), 2006.
2. Intellectual Property rights and copyrights, EssEss Publications.
3. Primer, R. Anita Rao and Bhanoji Rao, Intellectual Property Rights, Lastain Book company.
4. Edited by Derek Bosworth and Elizabeth Webster, The Management of Intellectual Property, Edward Elgar Publishing Ltd., 2006.
5. WIPO Intellectual Property Hand book.

COURSE OBJECTIVE

- To help students develop knowledge and competence in ethical management and decision making in organizational contexts.

UNIT I ETHICS AND SOCIETY**9**

Ethical Management- Definition, Motivation, Advantages-Practical implications of ethical management. Managerial ethics, professional ethics, and social Responsibility-Role of culture and society's expectations- Individual and organizational responsibility to society and the community.

UNIT II ETHICAL DECISION MAKING AND MANAGEMENT IN A CRISIS**9**

Managing in an ethical crisis, the nature of a crisis, ethics in crisis management, discuss case studies, analyze real-world scenarios, develop ethical management skills, knowledge, and competencies. Proactive crisis management.

UNIT III STAKEHOLDERS IN ETHICAL MANAGEMENT**9**

Stakeholders in ethical management, identifying internal and external stakeholders, nature of stakeholders, ethical management of various kinds of stakeholders: customers (product and service issues), employees (leadership, fairness, justice, diversity) suppliers, collaborators, business, community, the natural environment (the sustainability imperative, green management, Contemporary issues).

UNIT IV INDIVIDUAL VARIABLES IN ETHICAL MANAGEMENT**9**

Understanding individual variables in ethics, managerial ethics, concepts in ethical psychology-ethical awareness, ethical courage, ethical judgment, ethical foundations, ethical emotions/intuitions/intensity. Utilization of these concepts and competencies for ethical decision-making and management.

UNIT V PRACTICAL FIELD-GUIDE, TECHNIQUES AND SKILLS**9**

Ethical management in practice, development of techniques and skills, navigating challenges and dilemmas, resolving issues and preventing unethical management proactively. Role modelling and creating a culture of ethical management and human flourishing.

TOTAL: 45 PERIODS**COURSE OUTCOMES**

- CO1: Role modelling and influencing the ethical and cultural context.
 CO2: Respond to ethical crises and proactively address potential crises situations.
 CO3: Understand and implement stakeholder management decisions.
 CO4: Develop the ability, knowledge, and skills for ethical management.
 CO5: Develop practical skills to navigate, resolve and thrive in management situations

REFERENCES

1. Brad Agle, Aaron Miller, Bill O' Rourke, The Business Ethics Field Guide: the essential companion to leading your career and your company, 2016.
2. Steiner & Steiner, Business, Government & Society: A managerial Perspective, 2011.
3. Lawrence & Weber, Business and Society: Stakeholders, Ethics, Public Policy, 2020.

COURSE OBJECTIVES:

1. To study about **Internet of Things** technologies and its role in real time applications.
2. To introduce the infrastructure required for IoT
3. To familiarize the accessories and communication techniques for IoT.
4. To provide insight about the embedded processor and sensors required for IoT
5. To familiarize the different platforms and Attributes for IoT

UNIT I INTRODUCTION TO INTERNET OF THINGS**9**

Overview, Hardware and software requirements for IOT, Sensor and actuators, Technology drivers, Business drivers, Typical IoT applications, Trends and implications.

UNIT II IOT ARCHITECTURE**9**

IoT reference model and architecture -Node Structure - Sensing, Processing, Communication, Powering, Networking - Topologies, Layer/Stack architecture, IoT standards, Cloud computing for IoT, Bluetooth, Bluetooth Low Energy beacons.

UNIT III PROTOCOLS AND WIRELESS TECHNOLOGIES FOR IOT**9****PROTOCOLS:**

NFC, SCADA and RFID, Zigbee MIPI, M-PHY, UniPro, SPMI, SPI, M-PCIe GSM, CDMA, LTE, GPRS, small cell.

Wireless technologies for IoT: WiFi (IEEE 802.11), Bluetooth/Bluetooth Smart, ZigBee/ZigBee Smart, UWB (IEEE 802.15.4), 6LoWPAN, Proprietary systems-Recent trends.

UNIT IV IOT PROCESSORS**9**

Services/Attributes: Big-Data Analytics for IOT, Dependability, Interoperability, Security, Maintainability.

Embedded processors for IOT :Introduction to Python programming -Building IOT with RASPBERRY PI and Arduino.

UNIT V CASE STUDIES**9**

Industrial IoT, Home Automation, smart cities, Smart Grid, connected vehicles, electric vehicle charging, Environment, Agriculture, Productivity Applications, IOT Defense

TOTAL: 45 PERIODS**COURSE OUTCOMES:**

At the end of this course, the students will have the ability to

CO1: Analyze the concepts of IoT and its present developments.

CO2: Compare and contrast different platforms and infrastructures available for IoT

CO3: Explain different protocols and communication technologies used in IoT

CO4: Analyze the big data analytic and programming of IoT

CO5: Implement IoT solutions for smart applications

REFERENCES:

1. ArshdeepBahga and VijaiMadiseti : A Hands-on Approach "Internet of Things", Universities Press 2015.
2. Oliver Hersent , David Boswarthick and Omar Elloumi " The Internet of Things", Wiley,2016.
3. Samuel Greengard, " The Internet of Things", The MIT press, 2015.
4. Adrian McEwen and Hakim Cassimally"Designing the Internet of Things "Wiley,2014.
5. Jean- Philippe Vasseur, Adam Dunkels, "Interconnecting Smart Objects with IP: The Next Internet" Morgan Kuffmann Publishers, 2010.
6. Adrian McEwen and Hakim Cassimally, "Designing the Internet of Things", John Wiley and sons, 2014.

7. Lingyang Song/DusitNiyato/ Zhu Han/ Ekram Hossain," Wireless Device-to-Device Communications and Networks, CAMBRIDGE UNIVERSITY PRESS,2015.
8. OvidiuVermesan and Peter Friess (Editors), "Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems", River Publishers Series in Communication, 2013.
9. Vijay Madiseti , ArshdeepBahga, "Internet of Things (A Hands on-Approach)", 2014.
10. Zach Shelby, Carsten Bormann, "6LoWPAN: The Wireless Embedded Internet", John Wiley and sons, 2009.
11. Lars T.Berger and Krzysztof Iniewski, "Smart Grid applications, communications and security", Wiley, 2015.
12. JanakaEkanayake, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama and Nick Jenkins, " Smart Grid Technology and Applications", Wiley, 2015.
13. UpenaDalal,"Wireless Communications & Networks,Oxford,2015.

ET4072

MACHINE LEARNING AND DEEP LEARNING

L T P C

3 0 0 3

COURSE OBJECTIVES:

The course is aimed at

1. Understanding about the learning problem and algorithms
2. Providing insight about neural networks
3. Introducing the machine learning fundamentals and significance
4. Enabling the students to acquire knowledge about pattern recognition.
5. Motivating the students to apply deep learning algorithms for solving real life problems.

UNIT I LEARNING PROBLEMS AND ALGORITHMS

9

Various paradigms of learning problems, Supervised, Semi-supervised and Unsupervised algorithms

UNIT II NEURAL NETWORKS

9

Differences between Biological and Artificial Neural Networks - Typical Architecture, Common Activation Functions, Multi-layer neural network, Linear Separability, Hebb Net, Perceptron, Adaline, Standard Back propagation Training Algorithms for Pattern Association - Hebb rule and Delta rule, Hetero associative, Auto associative, Kohonen Self Organising Maps, Examples of Feature Maps, Learning Vector Quantization, Gradient descent, Boltzmann Machine Learning.

UNIT III MACHINE LEARNING – FUNDAMENTALS & FEATURE SELECTIONS & CLASSIFICATIONS

9

Classifying Samples: The confusion matrix, Accuracy, Precision, Recall, F1- Score, the curse of dimensionality, training, testing, validation, cross validation, overfitting, under-fitting the data, early stopping, regularization, bias and variance. Feature Selection, normalization, dimensionality reduction, Classifiers: KNN, SVM, Decision trees, Naïve Bayes, Binary classification, multi class classification, clustering.

UNIT IV DEEP LEARNING: CONVOLUTIONAL NEURAL NETWORKS

9

Feed forward networks, Activation functions, back propagation in CNN, optimizers, batch normalization, convolution layers, pooling layers, fully connected layers, dropout, Examples of CNNs.

UNIT V DEEP LEARNING: RNNs, AUTOENCODERS AND GANS

9

State, Structure of RNN Cell, LSTM and GRU, Time distributed layers, Generating Text, Autoencoders: Convolutional Autoencoders, Denoising autoencoders, Variational autoencoders, GANs: The discriminator, generator, DCGANs

TOTAL : 45 PERIODS

COURSE OUTCOMES (CO):

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

CO1 : Illustrate the categorization of machine learning algorithms.

CO2: Compare and contrast the types of neural network architectures, activation functions

CO3: Acquaint with the pattern association using neural networks

CO4: Elaborate various terminologies related with pattern recognition and architectures of convolutional neural networks

CO5: Construct different feature selection and classification techniques and advanced neural network architectures such as RNN, Autoencoders, and GANs.

REFERENCES:

1. J. S. R. Jang, C. T. Sun, E. Mizutani, Neuro Fuzzy and Soft Computing - A Computational Approach to Learning and Machine Intelligence, 2012, PHI learning
2. Deep Learning, Ian Good fellow, YoshuaBengio and Aaron Courville, MIT Press, ISBN: 9780262035613, 2016.
3. The Elements of Statistical Learning. Trevor Hastie, Robert Tibshirani and Jerome Friedman. Second Edition. 2009.
4. Pattern Recognition and Machine Learning. Christopher Bishop. Springer. 2006.
5. Understanding Machine Learning. Shai Shalev-Shwartz and Shai Ben-David. Cambridge University Press. 2017.

PX4012

RENEWABLE ENERGY TECHNOLOGY

L T P C
3 0 0 3

OBJECTIVES:

To impart knowledge on

- Different types of renewable energy technologies
- Standalone operation, grid connected operation of renewable energy systems

UNIT I INTRODUCTION

9

Classification of energy sources – Co2 Emission - Features of Renewable energy - Renewable energy scenario in India -Environmental aspects of electric energy conversion: impacts of renewable energy generation on environment Per Capital Consumption - CO₂ Emission - importance of renewable energy sources, Potentials – Achievements– Applications.

UNIT II SOLAR PHOTOVOLTAICS

9

Solar Energy: Sun and Earth-Basic Characteristics of solar radiation- angle of sunrays on solar collector-Estimating Solar Radiation Empirically - Equivalent circuit of PV Cell- Photovoltaic cell-characteristics: P-V and I-V curve of cell-Impact of Temperature and Insolation on I-V characteristics-Shading Impacts on I-V characteristics-Bypass diode -Blocking diode.

UNIT III PHOTOVOLTAIC SYSTEM DESIGN

9

Block diagram of solar photo voltaic system : Line commutated converters (inversion mode) - Boost and buck-boost converters - selection of inverter, battery sizing, array sizing - PV systems classification- standalone PV systems - Grid tied and grid interactive inverters- grid connection issues.

UNIT IV WIND ENERGY CONVERSION SYSTEMS

9

Origin of Winds: Global and Local Winds- Aerodynamics of Wind turbine-Derivation of Betz's limit-Power available in wind-Classification of wind turbine: Horizontal Axis wind turbine and Vertical axis wind turbine- Aerodynamic Efficiency-Tip Speed-Ratio-Solidity-Blade Count-Power curve of wind turbine - Configurations of wind energy conversion systems: Type A, Type B, Type C and Type D Configurations- Grid connection Issues - Grid integrated SCIG and PMSG based WECS.

UNIT V OTHER RENEWABLE ENERGY SOURCES

9

Qualitative study of different renewable energy resources: ocean, Biomass, Hydrogen energy systems, Fuel cells, Ocean Thermal Energy Conversion (OTEC), Tidal and wave energy, Geothermal Energy Resources.

TOTAL : 45 PERIODS

OUTCOMES:

After completion of this course, the student will be able to:

- CO1:** Demonstrate the need for renewable energy sources.
- CO2:** Develop a stand-alone photo voltaic system and implement a maximum power point tracking in the PV system.
- CO3:** Design a stand-alone and Grid connected PV system.
- CO4:** Analyze the different configurations of the wind energy conversion systems.
- CO5:** Realize the basic of various available renewable energy sources

REFERENCES:

1. S.N.Bhadra, D. Kastha, & S. Banerjee "Wind Electrical Systems", Oxford University Press, 2009.
2. Rai. G.D, "Non conventional energy sources", Khanna publishes, 1993.
3. Rai. G.D," Solar energy utilization", Khanna publishes, 1993.
4. Chetan Singh Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI Learning Private Limited, 2012.
5. John Twideu and Tony Weir, "Renewal Energy Resources" BSP Publications, 2006
6. Gray, L. Johnson, "Wind energy system", prentice hall of India, 1995.
7. B.H.Khan, " Non-conventional Energy sources", , McGraw-hill, 2nd Edition, 2009.
8. Fang Lin Luo Hong Ye, " Renewable Energy systems", Taylor & Francis Group,2013.

PS4093

SMART GRID

L T P C
3 0 0 3

COURSE OBJECTIVES

- To Study about Smart Grid technologies, different smart meters and advanced metering infrastructure.
- To know about the function of smart grid.
- To familiarize the power quality management issues in Smart Grid.
- To familiarize the high performance computing for Smart Grid applications
- To get familiarized with the communication networks for Smart Grid applications

UNIT I INTRODUCTION TO SMART GRID

9

Evolution of Electric Grid, Concept, Definitions and Need for Smart Grid, Smart grid drivers, functions, opportunities, challenges and benefits, Difference between conventional & Smart Grid, Comparison of Micro grid and Smart grid, Present development & International policies in Smart Grid, Smart Grid Initiative for Power Distribution Utility in India – Case Study.

UNIT II SMART GRID TECHNOLOGIES

9

Technology Drivers, Smart Integration of energy resources, Smart substations, Substation Automation, Feeder Automation ,Transmission systems: EMS, FACTS and HVDC, Wide area monitoring, Protection and control, Distribution systems: DMS, Volt/Var control, Fault Detection, Isolation and service restoration, Outage management, High-Efficiency Distribution Transformers, Phase Shifting Transformers, Plug in Hybrid Electric Vehicles (PHEV) – Grid to Vehicle and Vehicle to Grid charging concepts.

UNIT III SMART METERS AND ADVANCED METERING INFRASTRUCTURE

9

Introduction to Smart Meters, Advanced Metering infrastructure (AMI) drivers and benefits, AMI protocols, standards and initiatives, AMI needs in the smart grid, Phasor Measurement Unit(PMU) & their application for monitoring & protection. Demand side management and demand response programs, Demand pricing and Time of Use, Real Time Pricing, Peak Time Pricing.

UNIT IV POWER QUALITY MANAGEMENT IN SMART GRID 9
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, Power Quality Audit.

Unit V HIGH PERFORMANCE COMPUTING FOR SMART GRID APPLICATIONS 9
Architecture and Standards -Local Area Network (LAN), House Area Network (HAN), Wide Area Network (WAN), Broadband over Power line (BPL), PLC, Zigbee, GSM, IP based Protocols, Basics of Web Service and CLOUD Computing, Cyber Security for Smart Grid.

TOTAL : 45 PERIODS

COURSE OUTCOME:

Students able to

CO1: Relate with the smart resources, smart meters and other smart devices.

CO2: Explain the function of Smart Grid.

CO3: Experiment the issues of Power Quality in Smart Grid.

CO4: Analyze the performance of Smart Grid.

CO5: Recommend suitable communication networks for smart grid applications

REFERENCES

1. Stuart Borlase 'Smart Grid: Infrastructure, Technology and Solutions', CRC Press 2012.
2. JanakaEkanayake, Nick Jenkins, KithsiriLiyanage, Jianzhong Wu, Akihiko Yokoyama, 'Smart Grid: Technology and Applications', Wiley, 2012.
3. Mini S. Thomas, John D McDonald, 'Power System SCADA and Smart Grids', CRC Press, 2015
4. Kenneth C.Budka, Jayant G. Deshpande, Marina Thottan, 'Communication Networks for Smart Grids', Springer, 2014
5. SMART GRID Fundamentals of Design and Analysis, James Momoh, IEEE press, A John Wiley & Sons, Inc., Publication.

CP4391

SECURITY PRACTICES

**L T P C
3 0 0 3**

COURSE OBJECTIVES:

- To learn the core fundamentals of system and web security concepts
- To have through understanding in the security concepts related to networks
- To deploy the security essentials in IT Sector
- To be exposed to the concepts of Cyber Security and cloud security
- To perform a detailed study of Privacy and Storage security and related Issues

UNIT I SYSTEM SECURITY 9

Model of network security – Security attacks, services and mechanisms – OSI security architecture -A Cryptography primer- Intrusion detection system- Intrusion Prevention system - Security web applications- Case study: OWASP - Top 10 Web Application Security Risks.

UNIT II NETWORK SECURITY 9

Internet Security - Intranet security- Local Area Network Security - Wireless Network Security - Wireless Sensor Network Security- Cellular Network Security - Mobile security - IOT security - Case Study - Kali Linux.

UNIT III SECURITY MANAGEMENT 9

Information security essentials for IT Managers- Security Management System - Policy Driven System Management- IT Security - Online Identity and User Management System. Case study: Metasploit

UNIT IV CYBER SECURITY AND CLOUD SECURITY 9
 Cyber Forensics- Disk Forensics – Network Forensics – Wireless Forensics – Database Forensics – Malware Forensics – Mobile Forensics – Email Forensics- Best security practices for automate Cloud infrastructure management – Establishing trust in IaaS, PaaS, and SaaS Cloud types. Case study: DVWA

UNIT V PRIVACY AND STORAGE SECURITY 9
 Privacy on the Internet - Privacy Enhancing Technologies - Personal privacy Policies - Detection of Conflicts in security policies- privacy and security in environment monitoring systems. Storage Area Network Security - Storage Area Network Security Devices - Risk management - Physical Security Essentials.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- CO1:** Understand the core fundamentals of system security
- CO2:** Apply the security concepts to wired and wireless networks
- CO3:** Implement and Manage the security essentials in IT Sector
- CO4:** Explain the concepts of Cyber Security and Cyber forensics
- CO5:** Be aware of Privacy and Storage security Issues.

REFERENCES

1. John R. Vacca, Computer and Information Security Handbook, Third Edition, Elsevier 2017
2. Michael E. Whitman, Herbert J. Mattord, Principles of Information Security, Seventh Edition, Cengage Learning, 2022
3. Richard E. Smith, Elementary Information Security, Third Edition, Jones and Bartlett Learning, 2019
4. Mayor, K.K.Mookhey, Jacopo Cervini, Fairuzan Roslan, Kevin Beaver, Metasploit Toolkit for Penetration Testing, Exploit Development and Vulnerability Research, Syngress publications, Elsevier, 2007. ISBN : 978-1-59749-074-0
5. John Sammons, "The Basics of Digital Forensics- The Primer for Getting Started in Digital Forensics", Syngress, 2012
6. Cory Altheide and Harlan Carvey, "Digital Forensics with Open Source Tools",2011 Syngress, ISBN: 9781597495875.
7. Siani Pearson, George Yee "Privacy and Security for Cloud Computing" Computer Communications and Networks, Springer, 2013.

MP4251

CLOUD COMPUTING TECHNOLOGIES

**L T P C
3 0 0 3**

COURSE OBJECTIVES:

- To gain expertise in Virtualization, Virtual Machines and deploy practical virtualization solution
- To understand the architecture, infrastructure and delivery models of cloud computing.
- To explore the roster of AWS services and illustrate the way to make applications in AWS
- To gain knowledge in the working of Windows Azure and Storage services offered by Windows Azure
- To develop the cloud application using various programming model of Hadoop and Aneka

UNIT I VIRTUALIZATION AND VIRTUALIZATION INFRASTRUCTURE 6
 Basics of Virtual Machines - Process Virtual Machines – System Virtual Machines –Emulation – Interpretation – Binary Translation - Taxonomy of Virtual Machines. Virtualization –Management Virtualization — Hardware Maximization – Architectures – Virtualization Management – Storage Virtualization – Network Virtualization- Implementation levels of virtualization – virtualization structure – virtualization of CPU, Memory and I/O devices – virtual clusters and Resource Management – Virtualization for data center automation

UNIT II CLOUD PLATFORM ARCHITECTURE 12

Cloud Computing: Definition, Characteristics - Cloud deployment models: public, private, hybrid, community – Categories of cloud computing: Everything as a service: Infrastructure, platform, software- A Generic Cloud Architecture Design – Layered cloud Architectural Development – Architectural Design Challenges

UNIT III AWS CLOUD PLATFORM - IAAS 9

Amazon Web Services: AWS Infrastructure- AWS API- AWS Management Console - Setting up AWS Storage - Stretching out with Elastic Compute Cloud - Elastic Container Service for Kubernetes- AWS Developer Tools: AWS Code Commit, AWS Code Build, AWS Code Deploy, AWS Code Pipeline, AWS code Star - AWS Management Tools: Cloud Watch, AWS Auto Scaling, AWS control Tower, Cloud Formation, Cloud Trail, AWS License Manager

UNIT IV PAAS CLOUD PLATFORM 9

Windows Azure: Origin of Windows Azure, Features, The Fabric Controller – First Cloud APP in Windows Azure- Service Model and Managing Services: Definition and Configuration, Service runtime API- Windows Azure Developer Portal- Service Management API- Windows Azure Storage Characteristics-Storage Services- REST API- Blops

UNIT V PROGRAMMING MODEL 9

Introduction to Hadoop Framework - Mapreduce, Input splitting, map and reduce functions, specifying input and output parameters, configuring and running a job –Developing Map Reduce Applications - Design of Hadoop file system –Setting up Hadoop Cluster- Aneka: Cloud Application Platform, Thread Programming, Task Programming and Map-Reduce Programming in Aneka

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- CO1:** Employ the concepts of virtualization in the cloud computing
- CO2:** Identify the architecture, infrastructure and delivery models of cloud computing
- CO3:** Develop the Cloud Application in AWS platform
- CO4:** Apply the concepts of Windows Azure to design Cloud Application
- CO5:** Develop services using various Cloud computing programming models.

REFERENCES

1. Bernard Golden, Amazon Web Service for Dummies, John Wiley & Sons, 2013.
2. Raoul Alongi, AWS: The Most Complete Guide to Amazon Web Service from Beginner to Advanced Level, Amazon Asia- Pacific Holdings Private Limited, 2019.
3. Sriram Krishnan, Programming: Windows Azure, O'Reilly,2010.
4. Rajkumar Buyya, Christian Vacchiola, S.Thamarai Selvi, Mastering Cloud Computing , McGraw Hill Education (India) Pvt. Ltd., 2013.
5. Danielle Ruest, Nelson Ruest, —Virtualization: A Beginner"s Guidell, McGraw-Hill Osborne Media, 2009.
6. Jim Smith, Ravi Nair , "Virtual Machines: Versatile Platforms for Systems and Processes", Elsevier/Morgan Kaufmann, 2005.
7. John W.Rittinghouse and James F.Ransome, "Cloud Computing: Implementation, Management, and Security", CRC Press, 2010.
8. Toby Velte, Anthony Velte, Robert Elsenpeter, "Cloud Computing, A Practical Approach", McGraw-Hill Osborne Media, 2009.
9. Tom White, "Hadoop: The Definitive Guide", Yahoo Press, 2012.

COURSE OBJECTIVES:

- To provide a sound knowledge in UI & UX
- To understand the need for UI and UX
- Research Methods used in Design
- Tools used in UI & UX
- Creating a wireframe and prototype

UNIT I UX LIFECYCLE TEMPLATE**8**

Introduction. A UX process lifecycle template. Choosing a process instance for your project. The system complexity space. Meet the user interface team. Scope of UX presence within the team. More about UX lifecycles. Business Strategy. Value Innovation. Validated User Research. Killer UX Design. The Blockbuster Value Proposition. What Is a Value Proposition?.

UNIT II CONTEXTUAL INQUIRY**10**

The system concept statement. User work activity data gathering. Look for emotional aspects of work practice. Abridged contextual inquiry process. Data-driven vs. model-driven inquiry. Organizing concepts: work roles and flow model. Creating and managing work activity notes. Constructing your work activity affinity diagram (WAAD). Abridged contextual analysis process. History of affinity diagrams.

UNIT III DESIGN THINKING, IDEATION, AND SKETCHING**9**

Design-informing models: second span of the bridge . Some general “how to” suggestions. A New example domain: slideshow presentations. User models. Usage models. Work environment models. Barrier summaries. Model consolidation. Protecting your sources. Abridged methods for design-informing models extraction. Design paradigms. Design thinking. Design perspectives. User personas. Ideation. Sketching

UNIT IV UX GOALS, METRICS, AND TARGETS**8**

Introduction. UX goals. UX target tables. Work roles, user classes, and UX goals. UX measures. Measuring instruments. UX metrics. Baseline level. Target level. Setting levels. Observed results. Practical tips and cautions for creating UX targets. How UX targets help manage the user experience engineering process.

UNIT V ANALYSING USER EXPERIENCE**10**

Sharpening Your Thinking Tools. UX Research and Strength of Evidence. Agile Personas. How to Prioritize Usability Problems. Creating Insights, Hypotheses and Testable Design Ideas. How to Manage Design Projects with User Experience Metrics. Two Measures that Will Justify Any Design Change. Evangelizing UX Research. How to Create a User Journey Map. Generating Solutions to Usability Problems. Building UX Research Into the Design Studio Methodology. Dealing with Common objections to UX Research. The User Experience Debrief Meeting. Creating a User Experience Dashboard.

SUGGESTED ACTIVITIES:

- 1: Hands on Design Thinking process for a product
- 2: Defining the Look and Feel of any new Project
- 3: Create a Sample Pattern Library for that product (Mood board, Fonts, Colors based on UI principles)
- 4: Identify a customer problem to solve.
- 5: Conduct end-to-end user research - User research, creating personas, Ideation process (User stories, Scenarios), Flow diagrams, Flow Mapping

TOTAL : 45 PERIODS

COURSE OUTCOMES:

CO1: Build UI for user Applications

CO2: Use the UI Interaction behaviors and principles

CO3: Evaluate UX design of any product or application

CO4: Demonstrate UX Skills in product development

CO5: Implement Sketching principles

REFERENCES

1. UX for Developers: How to Integrate User-Centered Design Principles Into Your Day-to-Day Development Work, Westley Knight. Apress, 2018
2. The UX Book: Process and Guidelines for Ensuring a Quality User Experience, Rex Hartson, Pardha Pyla. Morgan Kaufmann, 2012
3. UX Fundamentals for Non-UX Professionals: User Experience Principles for Managers, Writers, Designers, and Developers, Edward Stull. Apress, 2018
4. Lean UX: Designing Great Products with Agile Teams, Gothelf, Jeff, Seiden, and Josh. O'Reilly Media, 2016
5. Designing UX: Prototyping: Because Modern Design is Never Static, Ben Coleman, and Dan Goodwin. SitePoint, 2017

MU4153

PRINCIPLES OF MULTIMEDIA

L T P C
3 0 0 3

COURSE OBJECTIVES:

- To get familiarity with gamut of multimedia and its significance
- To acquire knowledge in multimedia components.
- To acquire knowledge about multimedia tools and authoring.
- To acquire knowledge in the development of multimedia applications.
- To explore the latest trends and technologies in multimedia

UNIT I INTRODUCTION

9

Introduction to Multimedia – Characteristics of Multimedia Presentation – Multimedia Components – Promotion of Multimedia Based Components – Digital Representation – Media and Data Streams – Multimedia Architecture – Multimedia Documents, Multimedia Tasks and Concerns, Production, sharing and distribution, Hypermedia, WWW and Internet, Authoring, Multimedia over wireless and mobile networks.

Suggested Activities:

1. Flipped classroom on media Components.
2. External learning – Interactive presentation.

Suggested Evaluation Methods:

1. Tutorial – Handling media components
2. Quizzes on different types of data presentation.

UNIT II ELEMENTS OF MULTIMEDIA

9

Text-Types, Font, Unicode Standard, File Formats, Graphics and Image data representations – data types, file formats, color models; video – color models in video, analog video, digital video, file formats, video display interfaces, 3D video and TV: Audio – Digitization, SNR, SQNR, quantization, audio quality, file formats, MIDI; Animation- Key Frames and Tweening, other Techniques, 2D and 3D Animation.

Suggested Activities:

1. Flipped classroom on different file formats of various media elements.
2. External learning – Adobe after effects, Adobe Media Encoder, Adobe Audition.

Suggested Evaluation Methods:

1. Demonstration on after effects animations.
2. Quizzes on file formats and color models.

UNIT III MULTIMEDIA TOOLS**9**

Authoring Tools – Features and Types – Card and Page Based Tools – Icon and Object Based Tools – Time Based Tools – Cross Platform Authoring Tools – Editing Tools – Painting and Drawing Tools – 3D Modeling and Animation Tools – Image Editing Tools – Sound Editing Tools – Digital Movie Tools.

Suggested Activities:

1. Flipped classroom on multimedia tools.
2. External learning – Comparison of various authoring tools.

Suggested Evaluation Methods:

1. Tutorial – Audio editing tool.
2. Quizzes on animation tools.

UNIT IV MULTIMEDIA SYSTEMS**9**

Compression Types and Techniques: CODEC, Text Compression: GIF Coding Standards, JPEG standard – JPEG 2000, basic audio compression – ADPCM, MPEG Psychoacoustics, basic Video compression techniques – MPEG, H.26X – Multimedia Database System – User Interfaces – OS Multimedia Support – Hardware Support – Real Time Protocols – Play Back Architectures – Synchronization – Document Architecture – Hypermedia Concepts: Hypermedia Design – Digital Copyrights, Content analysis.

Suggested Activities:

1. Flipped classroom on concepts of multimedia hardware architectures.
2. External learning – Digital repositories and hypermedia design.

Suggested Evaluation Methods:

1. Quizzes on multimedia hardware and compression techniques.
2. Tutorial – Hypermedia design.

UNIT V MULTIMEDIA APPLICATIONS FOR THE WEB AND MOBILE PLATFORMS**9**

ADDIE Model – Conceptualization – Content Collection – Storyboard–Script Authoring Metaphors – Testing – Report Writing – Documentation. Multimedia for the web and mobile platforms. Virtual Reality, Internet multimedia content distribution, Multimedia Information sharing – social media sharing, cloud computing for multimedia services, interactive cloud gaming. Multimedia information retrieval.

Suggested Activities:

1. External learning – Game consoles.
2. External learning – VRML scripting languages.

Suggested Evaluation Methods:

1. Demonstration of simple interactive games.
2. Tutorial – Simple VRML program.

TOTAL : 45 PERIODS**COURSE OUTCOMES:**

CO1:Handle the multimedia elements effectively.

CO2:Articulate the concepts and techniques used in multimedia applications.

CO3:Develop effective strategies to deliver Quality of Experience in multimedia applications.

CO4:Design and implement algorithms and techniques applied to multimedia objects.

CO5:Design and develop multimedia applications following software engineering models.

REFERENCES:

1. Li, Ze-Nian, Drew, Mark, Liu, Jiangchuan, "Fundamentals of Multimedia", Springer, Third Edition, 2021.
2. Prabhat K. Andleigh, Kiran Thakrar, "MULTIMEDIA SYSTEMS DESIGN", Pearson Education, 2015.
3. Gerald Friedland, Ramesh Jain, "Multimedia Computing", Cambridge University Press, 2018. (digital book)
4. Ranjan Parekh, "Principles of Multimedia", Second Edition, McGraw-Hill Education, 2017

DS4015

BIG DATA ANALYTICS

L T P C
3 0 0 3

COURSE OBJECTIVES:

- To understand the basics of big data analytics
- To understand the search methods and visualization
- To learn mining data streams
- To learn frameworks
- To gain knowledge on R language

UNIT I INTRODUCTION TO BIG DATA 9

Introduction to Big Data Platform – Challenges of Conventional Systems - Intelligent data analysis – Nature of Data - Analytic Processes and Tools - Analysis Vs Reporting - Modern Data Analytic Tools- Statistical Concepts: Sampling Distributions - Re-Sampling - Statistical Inference - Prediction Error.

UNIT II SEARCH METHODS AND VISUALIZATION 9

Search by simulated Annealing – Stochastic, Adaptive search by Evaluation – Evaluation Strategies – Genetic Algorithm – Genetic Programming – Visualization – Classification of Visual Data Analysis Techniques – Data Types – Visualization Techniques – Interaction techniques – Specific Visual data analysis Techniques

UNIT III MINING DATA STREAMS 9

Introduction To Streams Concepts – Stream Data Model and Architecture - Stream Computing - Sampling Data in a Stream – Filtering Streams – Counting Distinct Elements in a Stream – Estimating Moments – Counting Oneness in a Window – Decaying Window - Real time Analytics Platform(RTAP) Applications - Case Studies - Real Time Sentiment Analysis, Stock Market Predictions

UNIT IV FRAMEWORKS 9

MapReduce – Hadoop, Hive, MapR – Sharding – NoSQL Databases - S3 - Hadoop Distributed File Systems – Case Study- Preventing Private Information Inference Attacks on Social Networks- Grand Challenge: Applying Regulatory Science and Big Data to Improve Medical Device Innovation

UNIT V R LANGUAGE 9

Overview, Programming structures: Control statements -Operators -Functions -Environment and scope issues -Recursion -Replacement functions, R data structures: Vectors -Matrices and arrays - Lists -Data frames -Classes, Input/output, String manipulations

TOTAL:45 PERIODS

COURSE OUTCOMES:

CO1: understand the basics of big data analytics

CO2: Ability to use Hadoop, Map Reduce Framework.

CO3: Ability to identify the areas for applying big data analytics for increasing the business outcome.

CO4: gain knowledge on R language

CO5: Contextually integrate and correlate large amounts of information to gain faster insights.

REFERENCE:

1. Michael Berthold, David J. Hand, Intelligent Data Analysis, Springer, 2007.
2. Anand Rajaraman and Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, 3rd edition 2020.
3. Norman Matloff, The Art of R Programming: A Tour of Statistical Software Design, No Starch Press, USA, 2011.
4. Bill Franks, Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics, John Wiley & sons, 2012.
5. Glenn J. Myatt, Making Sense of Data, John Wiley & Sons, 2007.

NC4201

INTERNET OF THINGS AND CLOUD

L T P C

3 0 0 3

COURSE OBJECTIVES:

- To understand Smart Objects and IoT Architectures
- To learn about various IOT-related protocols
- To build simple IoT Systems using Arduino and Raspberry Pi.
- To understand data analytics and cloud in the context of IoT
- To develop IoT infrastructure for popular applications

UNIT I FUNDAMENTALS OF IoT

9

Introduction to IoT – IoT definition – Characteristics – IoT Complete Architectural Stack – IoT enabling Technologies – IoT Challenges. Sensors and Hardware for IoT – Hardware Platforms – Arduino, Raspberry Pi, Node MCU. A Case study with any one of the boards and data acquisition from sensors.

UNIT II PROTOCOLS FOR IoT

9

Infrastructure protocol (IPV4/V6/RPL), Identification (URIs), Transport (Wifi, Lifi, BLE), Discovery, Data Protocols, Device Management Protocols. – A Case Study with MQTT/CoAP usage-IoT privacy, security and vulnerability solutions.

UNIT III CASE STUDIES/INDUSTRIAL APPLICATIONS

9

Case studies with architectural analysis: IoT applications – Smart City – Smart Water – Smart Agriculture – Smart Energy – Smart Healthcare – Smart Transportation – Smart Retail – Smart waste management.

UNIT IV CLOUD COMPUTING INTRODUCTION

9

Introduction to Cloud Computing - Service Model – Deployment Model- Virtualization Concepts – Cloud Platforms – Amazon AWS – Microsoft Azure – Google APIs.

UNIT V IoT AND CLOUD

9

IoT and the Cloud - Role of Cloud Computing in IoT - AWS Components - S3 – Lambda - AWS IoT Core -Connecting a web application to AWS IoT using MQTT- AWS IoT Examples. Security Concerns, Risk Issues, and Legal Aspects of Cloud Computing- Cloud Data Security

TOTAL:45 PERIODS

COURSE OUTCOMES:

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

CO1: Understand the various concept of the IoT and their technologies..

CO2: Develop IoT application using different hardware platforms

CO3: Implement the various IoT Protocols

CO4: Understand the basic principles of cloud computing.

CO5: Develop and deploy the IoT application into cloud environment

REFERENCES

1. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman ,CRC Press, 2017
2. Adrian McEwen, Designing the Internet of Things, Wiley,2013.
3. EMC Education Services, "Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data", Wiley publishers, 2015.
4. Simon Walkowiak, "Big Data Analytics with R" PackT Publishers, 2016
5. Bart Baesens, "Analytics in a Big Data World: The Essential Guide to Data Science and its Applications", Wiley Publishers, 2015.

MX4073

MEDICAL ROBOTICS

L T P C
3 0 0 3

COURSE OBJECTIVES:

- To explain the basic concepts of robots and types of robots
- To discuss the designing procedure of manipulators, actuators and grippers
- To impart knowledge on various types of sensors and power sources
- To explore various applications of Robots in Medicine
- To impart knowledge on wearable robots

UNIT I INTRODUCTION TO ROBOTICS

9

Introduction to Robotics, Overview of robot subsystems, Degrees of freedom, configurations and concept of workspace, Dynamic Stabilization

Sensors and Actuators

Sensors and controllers, Internal and external sensors, position, velocity and acceleration sensors, Proximity sensors, force sensors Pneumatic and hydraulic actuators, Stepper motor control circuits, End effectors, Various types of Grippers, PD and PID feedback actuator models

UNIT II MANIPULATORS & BASIC KINEMATICS

9

Construction of Manipulators, Manipulator Dynamic and Force Control, Electronic and pneumatic manipulator, Forward Kinematic Problems, Inverse Kinematic Problems, Solutions of Inverse Kinematic problems

Navigation and Treatment Planning

Variable speed arrangements, Path determination – Machinery vision, Ranging – Laser – Acoustic, Magnetic, fiber optic and Tactile sensor

UNIT III SURGICAL ROBOTS

9

Da Vinci Surgical System, Image guided robotic systems for focal ultrasound based surgical applications, System concept for robotic Tele-surgical system for off-pump, CABG surgery, Urologic applications, Cardiac surgery, Neuro-surgery, Pediatric and General Surgery, Gynecologic Surgery, General Surgery and Nanorobotics. Case Study

UNIT IV REHABILITATION AND ASSISTIVE ROBOTS

9

Pediatric Rehabilitation, Robotic Therapy for the Upper Extremity and Walking, Clinical-Based Gait Rehabilitation Robots, Motion Correlation and Tracking, Motion Prediction, Motion Replication. Portable Robot for Tele rehabilitation, Robotic Exoskeletons – Design considerations, Hybrid assistive limb. Case Study

UNIT V WEARABLE ROBOTS

9

Augmented Reality, Kinematics and Dynamics for Wearable Robots, Wearable Robot technology, Sensors, Actuators, Portable Energy Storage, Human–robot cognitive interaction (cHRI), Human–robot physical interaction (pHRI), Wearable Robotic Communication - case study

TOTAL:45 PERIODS

COURSE OUTCOMES:

CO1: Describe the configuration, applications of robots and the concept of grippers and actuators

CO2: Explain the functions of manipulators and basic kinematics

CO3: Describe the application of robots in various surgeries

CO4: Design and analyze the robotic systems for rehabilitation

CO5: Design the wearable robots

REFERENCES

1. Nagrath and Mittal, "Robotics and Control", Tata McGraw Hill, First edition, 2003
2. Spong and Vidhyasagar, "Robot Dynamics and Control", John Wiley and Sons, First edition, 2008
3. Fu.K.S, Gonzalez. R.C., Lee, C.S.G, "Robotics, control", sensing, Vision and Intelligence, Tata McGraw Hill International, First edition, 2008
4. Bruno Siciliano, Oussama Khatib, Springer Handbook of Robotics, 1st Edition, Springer, 2008
5. Shane (S.Q.) Xie, Advanced Robotics for Medical Rehabilitation - Current State of the Art and Recent Advances, Springer, 2016
6. Sashi S Kommu, Rehabilitation Robotics, I-Tech Education and Publishing, 2007
7. Jose L. Pons, Wearable Robots: Biomechatronic Exoskeletons, John Wiley & Sons Ltd, England, 2008
8. Howie Choset, Kevin Lynch, Seth Hutchinson, "Principles of Robot Motion: Theory, Algorithms, and Implementations", Prentice Hall of India, First edition, 2005
9. Philippe Coiffet, Michel Chirouze, "An Introduction to Robot Technology", Tata McGraw Hill, First Edition, 1983
10. Jacob Rosen, Blake Hannaford & Richard M Satava, "Surgical Robotics: System Applications & Visions", Springer 2011
11. Jocelyn Troccaz, Medical Robotics, Wiley, 2012
12. Achim Schweikard, Floris Ernst, Medical Robotics, Springer, 2015

VE4202

EMBEDDED AUTOMATION

L T P C
3 0 0 3

COURSE OBJECTIVES:

- To learn about the process involved in the design and development of real-time embedded system
- To develop the embedded C programming skills on 8-bit microcontroller
- To study about the interfacing mechanism of peripheral devices with 8-bit microcontrollers
- To learn about the tools, firmware related to microcontroller programming
- To build a home automation system

UNIT I INTRODUCTION TO EMBEDDED C PROGRAMMING

9

C Overview and Program Structure - C Types, Operators and Expressions - C Control Flow - C Functions and Program Structures - C Pointers And Arrays - FIFO and LIFO - C Structures - Development Tools

UNIT II AVR MICROCONTROLLER

9

ATMEGA 16 Architecture - Nonvolatile and Data Memories - Port System - Peripheral Features : Time Base, Timing Subsystem, Pulse Width Modulation, USART, SPI, Two Wire Serial Interface, ADC, Interrupts - Physical and Operating Parameters

UNIT III **HARDWARE AND SOFTWARE INTERFACING WITH 8-BIT SERIES CONTROLLERS** **9**
 Lights and Switches - Stack Operation - Implementing Combinational Logic - Expanding I/O - Interfacing Analog To Digital Convertors - Interfacing Digital To Analog Convertors - LED Displays : Seven Segment Displays, Dot Matrix Displays - LCD Displays - Driving Relays - Stepper Motor Interface - Serial EEPROM - Real Time Clock - Accessing Constants Table - Arbitrary Waveform Generation - Communication Links - System Development Tools

UNIT IV **VISION SYSTEM** **9**
 Fundamentals of Image Processing - Filtering - Morphological Operations - Feature Detection and Matching - Blurring and Sharpening - Segmentation - Thresholding - Contours - Advanced Contour Properties - Gradient - Canny Edge Detector - Object Detection - Background Subtraction

UNIT V **HOME AUTOMATION** **9**
 Home Automation - Requirements - Water Level Notifier - Electric Guard Dog - Tweeting Bird Feeder - Package Delivery Detector - Web Enabled Light Switch - Curtain Automation - Android Door Lock - Voice Controlled Home Automation - Smart Lighting - Smart Mailbox - Electricity Usage Monitor - Proximity Garage Door Opener - Vision Based Authentic Entry System

TOTAL: 45 PERIODS

COURSE OUTCOMES:

- On successful completion of this course, students will be able to
CO1: analyze the 8-bit series microcontroller architecture, features and pin details
CO2: write embedded C programs for embedded system application
CO3: design and develop real time systems using AVR microcontrollers
CO4: design and develop the systems based on vision mechanism
CO5: design and develop a real time home automation system

REFERENCES:

1. Dhananjay V. Gadre, "Programming and Customizing the AVR Microcontroller", McGraw-Hill, 2001.
2. Joe Pardue, "C Programming for Microcontrollers ", Smiley Micros, 2005.
3. Steven F. Barrett, Daniel J. Pack, "ATMEL AVR Microcontroller Primer : Programming and Interfacing", Morgan & Claypool Publishers, 2012
4. Mike Riley, "Programming Your Home - Automate With Arduino, Android and Your Computer", the Pragmatic Programmers, Llc, 2012.
5. Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer, 2011.
6. Kevin P. Murphy, "Machine Learning - a Probabilistic Perspective", the MIT Press Cambridge, Massachusetts, London, 2012.

CX4016	ENVIRONMENTAL SUSTAINABILITY	L	T	P	C
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UNIT I **INTRODUCTION** **9**
 Valuing the Environment: Concepts, Valuing the Environment: Methods, Property Rights, Externalities, and Environmental Problems

UNIT II **CONCEPT OF SUSTAINABILITY** **9**
 Sustainable Development: Defining the Concept, the Population Problem, Natural Resource Economics: An Overview, Energy, Water, Agriculture

UNIT III **SIGNIFICANCE OF BIODIVERSITY** **9**
 Biodiversity, Forest Habitat, Commercially Valuable Species, Stationary - Source Local Air Pollution, Acid Rain and Atmospheric Modification, Transportation

UNIT IV POLLUTION IMPACTS 9
Water Pollution, Solid Waste and Recycling, Toxic Substances and Hazardous Wastes, Global Warming.

UNIT V ENVIRONMENTAL ECONOMICS 9
Development, Poverty, and the Environment, Visions of the Future, Environmental economics and policy by Tom Tietenberg, Environmental Economics

TOTAL : 45 PERIODS

REFERENCES

1. Andrew Hoffman, Competitive Environmental Strategy - A Guide for the Changing Business Landscape, Island Press.
2. Stephen Doven, Environment and Sustainability Policy: Creation, Implementation, Evaluation, the Federation Press, 2005
3. Robert Brinkmann., Introduction to Sustainability, Wiley-Blackwell., 2016
4. Niko Roorda., Fundamentals of Sustainable Development, 3rd Edn, Routledge, 2020
5. Bhavik R Bakshi., Sustainable Engineering: Principles and Practice, Cambridge University Press, 2019

**TX4092 TEXTILE REINFORCED COMPOSITES L T P C
3 0 0 3**

UNIT I REINFORCEMENTS 9
Introduction – composites –classification and application; reinforcements- fibres and its properties; preparation of reinforced materials and quality evaluation; preforms for various composites

UNIT II MATRICES 9
Preparation, chemistry, properties and applications of thermoplastic and thermoset resins; mechanism of interaction of matrices and reinforcements; optimization of matrices

UNIT III COMPOSITE MANUFACTURING 9
Classification; methods of composites manufacturing for both thermoplastics and thermosets- Hand layup, Filament Winding, Resin transfer moulding, prepregs and autoclave moulding, pultrusion, vacuum impregnation methods, compression moulding; post processing of composites and composite design requirements

UNIT IV TESTING 9
Fibre volume and weight fraction, specific gravity of composites, tensile, flexural, impact, compression, inter laminar shear stress and fatigue properties of thermoset and thermoplastic composites.

UNIT V MECHANICS 9
Micro mechanics, macro mechanics of single layer, macro mechanics of laminate, classical lamination theory, failure theories and prediction of inter laminar stresses using at ware

TOTAL: 45 PERIODS

REFERENCES

1. BorZ.Jang, "Advanced Polymer composites", ASM International, USA, 1994.
2. Carlsson L.A. and Pipes R.B., "Experimental Characterization of advanced composite Materials", Second Edition, CRC Press, New Jersey, 1996.
3. George Lubin and Stanley T. Peters, "Handbook of Composites", Springer Publications, 1998.
4. Mel. M. Schwartz, "Composite Materials", Vol. 1 & 2, Prentice Hall PTR, New Jersey, 1997.
5. Richard M. Christensen, "Mechanics of composite materials", Dover Publications, 2005.
6. Sanjay K. Mazumdar, "Composites Manufacturing: Materials, Product, and Process Engineering", CRC Press, 2001

- UNIT I BASICS OF NANOCOMPOSITES 9**
Nomenclature, Properties, features and processing of nanocomposites. Sample Preparation and Characterization of Structure and Physical properties. Designing, stability and mechanical properties and applications of super hard nanocomposites.
- UNIT II METAL BASED NANOCOMPOSITES 9**
Metal-metal nanocomposites, some simple preparation techniques and their properties. Metal-Oxide or Metal-Ceramic composites, Different aspects of their preparation techniques and their final properties and functionality. Fractal based glass-metal nanocomposites, its designing and fractal dimension analysis. Core-Shell structured nanocomposites
- UNIT III POLYMER BASED NANOCOMPOSITES 9**
Preparation and characterization of diblock Copolymer based nanocomposites; Polymer Carbon nanotubes based composites, their mechanical properties, and industrial possibilities.
- UNIT IV NANOCOMPOSITE FROM BIOMATERIALS 9**
Natural nanocomposite systems - spider silk, bones, shells; organic-inorganic nanocomposite formation through self-assembly. Biomimetic synthesis of nanocomposites material; Use of synthetic nanocomposites for bone, teeth replacement.
- UNIT V NANOCOMPOSITE TECHNOLOGY 9**
Nanocomposite membrane structures- Preparation and applications. Nanotechnology in Textiles and Cosmetics-Nano-fillers embedded polypropylene fibers – Soil repellence, Lotus effect - Nano finishing in textiles (UV resistant, anti-bacterial, hydrophilic, self-cleaning, flame retardant finishes), Sun-screen dispersions for UV protection using titanium oxide – Colour cosmetics. Nanotechnology in Food Technology - Nanopackaging for enhanced shelf life - Smart/Intelligent packaging.

TOTAL : 45 PERIODS

REFERENCES:

1. Introduction to Nanocomposite Materials. Properties, Processing, Characterization- Thomas E. Twardowski. 2007. DEStech Publications. USA.
2. Nanocomposites Science and Technology - P. M. Ajayan, L.S. Schadler, P. V. Braun 2006.
3. Physical Properties of Carbon Nanotubes- R. Saito 1998.
4. Carbon Nanotubes (Carbon , Vol 33) - M. Endo, S. Iijima, M.S. Dresselhaus 1997.
5. The search for novel, superhard materials- Stan Veprjek (Review Article) JVST A, 1999
6. Nanometer versus micrometer-sized particles-Christian Brosseau, Jamal BeN Youssef, Philippe Talbot, Anne-Marie Konn, (Review Article) J. Appl. Phys, Vol 93, 2003
7. Diblock Copolymer, - Aviram (Review Article), Nature, 2002
8. Bikramjit Basu, Kantesh Balani Advanced Structural Ceramics, A John Wiley & Sons, Inc.,
9. P. Brown and K. Stevens, Nanofibers and Nanotechnology in Textiles, Woodhead publication, London, 2006

UNIT I IPR**9**

Intellectual property rights – Origin of the patent regime – Early patents act & Indian pharmaceutical industry – Types of patents – Patent Requirements – Application preparation filing and prosecution – Patentable subject matter – Industrial design, Protection of GMO's IP as a factor in R&D, IP's of relevance to biotechnology and few case studies.

UNIT II AGREEMENTS, TREATIES AND PATENT FILING PROCEDURES**9**

History of GATT Agreement – Madrid Agreement – Hague Agreement – WIPO Treaties – Budapest Treaty – PCT – Ordinary – PCT – Conventional – Divisional and Patent of Addition – Specifications – Provisional and complete – Forms and fees Invention in context of “prior art” – Patent databases – Searching International Databases – Country-wise patent searches (USPTO, espacenet(EPO) – PATENT Scope (WIPO) – IPO, etc National & PCT filing procedure – Time frame and cost – Status of the patent applications filed – Precautions while patenting – disclosure/non-disclosure – Financial assistance for patenting – Introduction to existing schemes Patent licensing and agreement Patent infringement – Meaning, scope, litigation, case studies

UNIT III BIOSAFETY**9**

Introduction – Historical Background – Introduction to Biological Safety Cabinets – Primary Containment for Biohazards – Biosafety Levels – Biosafety Levels of Specific Microorganisms – Recommended Biosafety Levels for Infectious Agents and Infected Animals – Biosafety guidelines – Government of India.

UNIT IV GENETICALLY MODIFIED ORGANISMS**9**

Definition of GMOs & LMOs – Roles of Institutional Biosafety Committee – RCGM – GEAC etc. for GMO applications in food and agriculture – Environmental release of GMOs – Risk Analysis – Risk Assessment – Risk management and communication – Overview of National Regulations and relevant International Agreements including Cartagena Protocol.

UNIT V ENTREPRENEURSHIP DEVELOPMENT**9**

Introduction – Entrepreneurship Concept – Entrepreneurship as a career – Entrepreneurial personality – Characteristics of successful Entrepreneur – Factors affecting entrepreneurial growth – Entrepreneurial Motivation – Competencies – Mobility – Entrepreneurship Development Programmes (EDP) - Launching Of Small Enterprise - Definition, Characteristics – Relationship between small and large units – Opportunities for an Entrepreneurial career – Role of small enterprise in economic development – Problems of small scale industries – Institutional finance to entrepreneurs - Institutional support to entrepreneurs.

TOTAL : 45 PERIODS**REFERENCES**

1. Bouchoux, D.E., “Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets for the Paralegal”, 3rd Edition, Delmar Cengage Learning, 2008.
2. Fleming, D.O. and Hunt, D.L., “Biological Safety: Principles and Practices”, 4th Edition, American Society for Microbiology, 2006.
3. Irish, V., “Intellectual Property Rights for Engineers”, 2nd Edition, The Institution of Engineering and Technology, 2005.
4. Mueller, M.J., “Patent Law”, 3rd Edition, Wolters Kluwer Law & Business, 2009.
5. Young, T., “Genetically Modified Organisms and Biosafety: A Background Paper for Decision- Makers and Others to Assist in Consideration of GMO Issues” 1st Edition, World Conservation Union, 2004.
6. S.S Khanka, “Entrepreneurial Development”, S.Chand & Company LTD, New Delhi, 2007.