Walchand College of Engineering, Sangli

(Government Aided Autonomous Institute)

AY 2021-22

Course Information	
Programme	M. Tech. Civil (Environmental Engineering)
Class, Semester	First Year M. Tech., Semester I
Course Code	5EV551
Course Name	Activity Based Lab: Physico-Chemical Methods for Water and Wastewater Treatment
Desired Requisites	Physico-Chemical Methods for Water and Wastewater Treatment

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	-	**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2				
Interaction	-	**Credits: 1**			

Course Objectives

1	To provide exposure to work on the real-life problems.
2	To provide an opportunity to contribute individually to the development of experimental set ups by applying the acquired technological knowledge.

Course Outcomes (CO) with Bloom's Taxonomy Level

CO1	Design experiments by applying the acquired knowledge on techniques and tools.	Create
CO2	Carry out experimental studies for characterization, parameter estimation, and performance evaluation independently and in teams.	Apply
CO3	Analyze, critique, and interpret experimental results through application of modern engineering tools and conclude based on the results.	Analyze Evaluate

List of project works

One from each group by each student

Group A (Laboratory based)

1. Study on performance of synthetic and natural coagulants for turbidity removal.
2. Water quality assessment for distributed water.
3. Defluoridation by activated carbon.
4. Water softening by synthetic resin.

Group B (Real-life system)

1. Oxygen transfer rate of cascade aerator in a real-life water treatment plant.
2. Effect of coagulation and flocculation in real-life water treatment plant for turbidity removal.
3. Efficiency of settling tank and filter for turbidity removal.
4. Assessment of membrane based water purifier.

Text Books

1	Peavy H, S, Rowe D, R, and Tchobanoglous G, "Environmental Engineering", McGraw-Hill Book Company, International edition, 1985.
2	Metcalf and Eddy "Wastewater Engineering Treatment and Reuse", Tata McGraw Hill Publication, 6th Reprint, 2003.

3	"Manual on water supply and Treatment", CPHEEO, Ministry of Urban Development, GoI, New Delhi, 1999.
References	
1	Sincero A, P and Sincero G, A, "Environmental Engineering A Design approach", PHI learning private limited, 2004.
2	Sawyer and McCarty, "Chemistry for Environmental Engineers", Tata McGraw Hill, 5th Edition, 2003.
3	Clesceri, L. S., Greenberg, A. E. and Eaton, A. D. (Eds), Standard Methods for the Examination of Water and Wastewater, Washington, D.C., 21st Ed., 2001.
4	Quasim, S. R., "Water treatment plants planning, design and operation", CRC Press, 2nd Edition, 2010.

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			3			
CO2			3			
CO3				3		

Assessment				
There are three components of lab assessment, LA1, LA2 and ESE				
Assessment	**Based on**	**Conducted by**	**Typical Schedule**	**Marks**
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 5 Marks Submission at the end of Week 5	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 6 to Week 10 Marks Submission at the end of Week 9	30
ESE	Lab Performance and documentation	Lab Course Faculty	During Week 10 to Week 15 Marks Submission at the end of Week 15	40
Week 1 indicates starting week of Semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.				

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**LA1**	**LA2**	**ESE**	**Total**
Remember				
Understand				
Apply	10	10	10	**30**
Analyse	10	10	10	**30**
Evaluate		10	10	**20**
Create	10		10	**20**
Total	**30**	**30**	**40**	**100**

Walchand College of Engineering, Sangli

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Course Information

Programme	M. Tech. Civil (Environmental Engineering)
Class, Semester	First Year M. Tech., Semester I
Course Code	5EV552
Course Name	Activity Based Lab: Municipal Solid Waste Management
Desired Requisites:	Municipal Solid Waste Management

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	-	**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2				
Interaction	-	**Credits: 1**			

Course Objectives

1	To provide hands on practice to analyze Municipal Solid Waste (MSW).
2	To provide knowledge to analyze environmental condition.

Course Outcomes (CO) with Bloom's Taxonomy Level

CO1	***Explain*** instrumentation required for characterization of municipal solid waste	Understand
CO2	***Use*** instrumentation for characterization of municipal solid waste	Apply
CO3	***Examine*** the results obtained through experimentation and ***Assess*** the prevailing environmental condition	Analyze Evaluate

List of Experiments / Lab Activities

Group A (Laboratory based):

1. Sampling of Municipal Solid Waste (MSW)
2. Proximate analysis of Municipal Solid Waste (MSW).
3. Ultimate analysis of Municipal Solid Waste (MSW).

At least two from Group B

Group B (Real life system):

1. Design a solid waste collection bin for collecting solid waste from colony/society.
2. Design a municipal solid waste collection route using suitable/available tools for small colony/society/village/town.
3. Design a solid waste processing unit for small colony/society/village/town.
4. Design a landfill/disposal facility for small colony/society/village/town.

Text Books

1	Tchobanoglous G., "Integrated Solid Waste Management", Tata McGraw-Hill Publishing Company Limited, 1st Edition, 1993.
2	CPHEEO, "Manual on Municipal Solid waste management", Central Public Health and Environmental Engineering Organization, Government of India, New Delhi, 2000
3	"Manual for wet and dry depositing", CPCB Methods, Central Lab test methods, 2001.

References

1	Sincero A. P. and Sincero G, A, "Environmental Engineering A Design approach", PHI learning Private limited, 2004.
2	Nathanson J. A. "Basic Environmental technology for water supply, waste management and Pollution control", PHI Publishing Company, 5th Edition, 2009.
3	Peavy, Rowe and Tchobanoglous, "Environmental Engineering", Tata McGraw-Hill Publishing Company Limited, 1st Edition, 1985.

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			2	3		
CO2				3		2
CO3				3		2

Assessment				
There are three components of lab assessment, LA1, LA2 and ESE				
Assessment	**Based on**	**Conducted by**	**Typical Schedule**	**Marks**
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 5 Marks Submission at the end of Week 5	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 6 to Week 10 Marks Submission at the end of Week 9	30
ESE	Lab Performance and documentation	Lab Course Faculty	During Week 10 to Week 15 Marks Submission at the end of Week 15	40
Week 1 indicates starting week of Semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.				

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**LA1**	**LA2**	**ESE**	**Total**
Remember				
Understand	10		10	**20**
Apply	10	10	10	**30**
Analyse	10	10	10	**30**
Evaluate		10	10	**20**
Create				
Total	**30**	**30**	**40**	**100**

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Course Information

Programme	M. Tech. Civil (Environmental Engineering)
Class, Semester	First Year M. Tech., Semester I
Course Code	5EV502
Course Name	Municipal Solid Waste Management
Desired Requisites:	Environmental Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs./week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 3**			

Course Objectives

1	Provide knowledge on functional elements of MSWM.
2	Impart basic skills for design and operation of MSWM systems.
3	Have overview of MSW rules and Government initiatives.

Course Outcomes (CO) with Bloom's Taxonomy Level

CO1	***Recognize*** fundamental elements of MSW and ***summarize*** practices for effective MSW management.	Remember Understand
CO2	***Apply*** the fundamental elements of MSWM to ***analyze*** collection, transportation, and processing of MSW.	Apply Analyze
CO3	***Evaluate*** processing and disposal system; and to ***devise*** suitable plans for rehabilitation of existing MSWM	Evaluate

Module	**Module Contents**	**Hours**
I	**Municipal Solid Waste Sources and Characterization** Sources, Types, Composition, Physical, Chemical and Biological properties. Solid Waste Management: Objectives, Functional elements, Environmental impact of mismanagement, Present Indian Scenario and scope to improve system for different functional elements of solid waste management system.	7
II	**Solid Waste Generation Rate & Transfer Station** Solid Waste Generation Rate: Definition, Typical values for Indian cities, Factors affecting. Storage and collection: General considerations for waste storage at source, Collection components, Types of collection systems and its design, Transportation of solid waste: Means and methods, Routing of vehicles. Transfer station: Need, Types, factors affecting Capacity, Location and economic Viability.	6
III	**Waste Processing Techniques & Material Recovery and Recycling** Waste Processing Techniques: Purpose, Mechanical volume and size reduction, component separation techniques. Material Recovery and Recycling: Objectives, Recycling program elements, Commonly recycled materials and processes. Energy recovery from solid waste: Parameters affecting, Fundamentals of thermal processing, Pyrolysis, Incineration, Refuse derived fuels, Energy recovery, case studies under Indian conditions.	7

IV	**Recovery of Biological Conversion Products: Compost and Biogas** Composting: Benefits, Processes, Stages, Technologies, Factors affecting properties of compost. Vermicomposting and Bio-methanation.	6
V	**Landfills** Site selection, Types, Principle, Processes, Land filling methods, Leachate and landfill gas management, Design of a landfill facility, closure, post-closure plans, and rehabilitation of dumpsites.	7
VI	**Overview of Municipal Solid Waste Rules and Government Initiatives** Waste Management legislation in India, integrated management-Public awareness; Role of NGO's; Introduction to various initiatives of the Govt. of India such as Swachh Bharat Mission, Smart Cities as well as Make in India; Biomedical; C and D waste Generation, identification, storage, collection, transport, treatment, and disposal, occupational hazards and safety measures.	7

Text Books	
1	Bhide. A. D. and Sundaresan. B. B., "Solid Waste Management", Indian National Scientific Documentation Centre, 1st Edition, 1983.
2	CPHEEO, "Manual on Municipal Solid waste management", Central Public Health and Environmental Engineering Organization, Government of India, New Delhi, 2000
3	Tchobanoglous G., "Integrated Solid Waste Management", Tata McGraw-Hill Publishing Company Limited, 1st Edition, 1993.

References	
1	Vesilind, Worrell and Reinhart, "Solid Waste Engineering", Cengage Learning India Pvt. Ltd.,
2	Masters G., "Introduction to Environmental Engineering and Science", Pearson Education, 2004
3	Peavy, Rowe and Tchobanoglous, "Environmental Engineering", Tata McGraw-Hill Publishing Company Limited, 1st Edition, 1985.
4	"MSW Rules 2016", Swachh Bharat Mission and Smart Cities Program of India.

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			3			
CO2				3		3
CO3				3		

Assessment
The assessment is based on 2 Tests (T1 & T2) of 20 marks each, and 1 end-semester examination (ESE) of 60 marks. Test 1 is typically based on the modules 1 & 2. Test 2 is based on modules 3 & 4 and ESE is based on all modules with 40-50% weightage on modules 1 to 4 and 50-60% weightage on modules 5 & 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember	5		10	**15**
Understand	5	5	5	**15**
Apply	5	5	15	**25**

Analyse	5	5	15	**25**
Evaluate		5	15	**20**
Create				
Total	**20**	**20**	**60**	**100**

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Course Information	
Programme	M. Tech. Civil (Environmental Engineering)
Class, Semester	First Year M. Tech., Semester I
Course Code	5EV512
Course Name	Geo-Environmental Engineering
Desired Requisites:	Soil Mechanics

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs./week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 3**			

Course Objectives	
1	To provide students the necessary knowledge and concepts in the field of Subsurface Contamination, their effects, detection and remedial measures.
2	To familiarize the students with types and properties of geo-synthetic materials, their use for various Civil engineering functions in general and for solid/slurry waste containment in particular.

Course Outcomes (CO) with Bloom's Taxonomy Level		
CO1	***Describe*** and ***Differentiate*** various engineering properties of soils, available geo synthetic materials, their properties and suitability.	Understand Analyze
CO2	***Calculate*** area requirement of landfill site and ***Evaluate*** compaction quality using field tests.	Analyze Evaluate
CO3	***Describe*** components of sanitary landfill sites and ***Analyze*** stability of landfill embankments, liners and covers.	Understand Analyze

Module	**Module Contents**	**Hours**
I	**Introduction to Geo-environmental Engineering** Introduction, overview of pollution, control and remediation, Case histories on Geo-environmental Engineering, Soils- Soil as 'Phased System', Soil classification, Various Soil Types with important engineering properties, their suitability for intended purpose, Clay Mineralogy.	7
II	**Contaminant Transport in Soil** Soil-water-contaminant interaction; Contaminant Transport, Geochemical Attenuation and attenuation capacity of soils. Zones of contaminant plume. Introduction to Detection of polluted zones and Monitoring designed system.	5
III	**Introduction to Geo-synthetic Materials** Various forms of Geo-synthetic material (GM, GT, GN, GG, GCL, GP, Geo-foam), Their general applications for various engineering functions. Various Geo-synthetic material properties. Use of Geo-synthetic material in waste containment. Concerns about use.	6
IV	**Solid Waste Containment**	12

	Site selection, Typical cross sections of landfills, merits and demerits. Area calculation of landfill site. EPA (MoEF and CPCB) Guidelines. CCL, GCL and composite liners. Compaction quality control for CC liners. Stability analysis of Landfills: Conventional Slope Stability analysis by method of slices, stability number concept. Stability against sliding of geo-membrane over clay (liner stability) and sliding of soil over geo-membrane (Cover stability). Assessment of anchorage requirement of GM.	
V	**Slurry Waste Containment** *Slurry Waste Containment:* Slurry transported wastes, pond layouts, components of pond, embankment construction, staged raising of embankment, Design aspects, environmental impact and control. *Vertical Barriers for Containment:* Various types of Cutoff Walls, Requirements of good vertical barriers, Slurry trench walls using Bentonite and Cement-bentonite slurry, material and construction aspects.	5
VI	**Geotechnical Reuse of Waste Material** Waste reduction, use of waste in geotechnical construction, Waste characteristics for soil replacement, Transport considerations, and engineering properties of waste.	5

Text Books	
1	G L SivakumarBabu, "Soil Reinforcement and Geosynthetics", Universities Press (India) Pvt. Ltd. Hyderabad, 2006.
2	S. K. Gulhati, ManojDatta, "Geotechnical Engineering", Tata McGraw Hill, New Delhi, 2005.
3	Braja Das, "Principles of Geotech. Engg", Thomson Asia Pvt. Ltd, 5th Edition, 2002.
4	Fang, H.Y, "Introduction to Environmental Geotechnology", CRC Press, 1997

References	
1	Donald Coduto, "Geotechnical Engineering Principles and Practices Prentice Hall of India Pvt. Ltd., New Delhi, 2002.
2	Daniel, D. E, "Geotechnical Practice for Waste Disposal", Chapman and Hall, 1993.
3	Koerner, R.M., "Designing with Geosynthetics", Fifth Edition, Prentice Hall, New Jersey, 2005.

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			2			
CO2			2			
CO3			3	1		1

Assessment
The assessment is based on 2 Tests (T1 & T2) of 20 marks each, and 1 end-semester examination (ESE) of 60 marks. Test 1 is typically based on the modules 1 & 2. Test 2 is based on modules 3 & 4 and ESE is based on all modules with 40-50% weightage on modules 1 to 4 and 50-60% weightage on modules 5 & 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand	5	5	20	**30**
Apply	10	5	20	**35**
Analyze	5	10	20	**35**
Evaluate				
Create				
Total	**20**	**20**	**60**	**100**

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Course Information	
Programme	M. Tech. Civil (Environmental Engineering)
Class, Semester	First Year M. Tech., Semester I
Course Code	5EV511
Course Name	Hydraulics of Transport Systems in Environmental Engineering
Desired Requisites:	Basic courses on hydraulics, water supply and sewerage

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs./week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 3**			

Course Objectives

1	Provide in-depth knowledge of hydraulics for analysis and evaluation of transport systems in Environmental Engineering
2	Enhance the technical competency and apply the acquired knowledge for research and development, industry, and consultancy activities.

Course Outcomes (CO) with Bloom's Taxonomy Level

CO1	***Explain*** and ***apply*** hydraulics of environmental facilities.	Understand Apply
CO2	***Analyze*** and ***evaluate*** the distribution and collection systems	Analyze Evaluate
CO3	***Design*** the distribution, collection and treatment facilities in environmental systems hydraulically	Create

Module	**Module Contents**	**Hours**
I	**Pumped and Gravity Water Mains** *Review of closed conduit hydraulics:* Continuity and Energy equation, Head loss calculations. *Sizing water mains:* Classification of problems, Design flow, Design of pumped and gravity system of water mains, Concept of Optimal design, Economic design of pumped and gravity water mains. *Pumping system:* Design of water pumping system.	5
II	**Water Distribution System (WDS)** *Water Distribution System (WDS):* Types of network, Water demand allocation, Types of problem, Network hydraulics, Types of simulation, Flow, node and loop equations *Analysis and Design of WDS:* Linear theory, and Newton-Raphson methods, Design and Use of optimization of WDS. *WDS testing:* Fundamentals, Pressure and flow measurement. *Calibration:* Overview of hydraulic calibration approaches. *Application of computer models:* WDS analysis and design, Identifying and solving common WDS problems, Extension of WDS, Rehabilitation, Calibration. *Pipe breaks and water loss:* Causes, Leak detection, Evaluation of leak detection.	10

III	**Sanitary Sewerage System** *Review of sewer hydraulics:* Velocity of flow, Hydraulic formulae, Gradient, types of sewer. *Design of sanitary sewerage system:* Estimation of design flow, Design considerations, Procedure, Design of sanitary sewer system, Use of computer models for design.	5
IV	**Stormwater Drainage System** Need and design objectives of stormwater conveyance system, System components and design process, Peak flow estimation by rational and SCS method, Hydraulic analysis of roadway gutter and inlets, Design of storm sewer system, Use of computer models for analysis and design.	5
V	**Plumbing and Rainwater Harvesting System** *Plumbing system:* Terminology, Principles of water supply and drainage system in buildings, Design of water supply and drainage system in multi-storeyed building. *Rainwater harvesting:* Need and concept of rainwater harvesting, Systems of rainwater harvesting, Roof top harvesting of rainwater, Components, Estimation of water collection potential, Design considerations, Design of a roof top harvesting system.	10
VI	**Hydraulic Design of Treatment Facilities** Hydraulic design of treatment facilities: Hydraulic design of water and wastewater treatment facilities, Preparation of hydraulic profiles, Plant layout.	5

Text Books	
1	Peavy H, S, Rowe D, R, and Tchobanoglous G, "Environmental Engineering", McGraw-Hill Book Company, Indian edition 2017.
2	Hammer M, J and Hammer M, J, "Water and Wastewater Technology", PHI learning private limited, 6th Edition, 2008.
3	Walski, Chase and Savic, "Water Distribution Modeling", Haestad Press, First edition, 2007.

References	
1	Sincero A, P and Sincero G, A, "Environmental Engineering A Design approach", PHI learning private limited, 2004.
2	"Manual on Water Supply and Treatment", CPHEEO, Ministry of Urban Development, GoI, New Delhi, 1999.
3	"Manual on Sewerage and Sewage Treatment", CPHEEO, Ministry of Urban Development, GoI, New Delhi, 1993.
4	Haestad-Durrans, "Storm water conveyance modeling and design", Haestad Press, 1st edition, 2003.

Useful Links	
1	https://www.youtube.com/channel/UCbFIgNot42PRCi-05X8aF_A

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			2			
CO2				3		
CO3				2		3

Assessment
The assessment is based on 2 Tests (T1 & T2) of 20 marks each, and 1 end-semester examination (ESE) of 60 marks. Test 1 is typically based on the modules 1 & 2. Test 2 is based on modules 3 & 4, and ESE is based on all modules with 40-50% weightage on modules 1 to 4 and 50-60% weightage on modules 5 & 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember	5		10	**15**
Understand	5	5	5	**15**
Apply	5	5	15	**25**
Analyze	5	5	15	**25**
Evaluate		5	15	**20**
Create				
Total	**20**	**20**	**60**	**100**

Walchand College of Engineering, Sangli *(Government Aided Autonomous Institute)*					
AY 2021-22					
Course Information					
Programme	M. Tech. Civil (Environmental Engineering)				
Class, Semester	First Year M. Tech., Semester I				
Course Code	5EV514				
Course Name	Computational Methods and Optimization Techniques				
Desired Requisites:	All Courses in Mathematics for UG				
Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs./week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 3**			

Course Objectives	
1	To provide knowledge of numerical approach and significance of error analysis.
2	To provide necessary knowledge of numerical tools required for analyzing and solving problems in the field of engineering.
3	To provide pre-requisite statistical knowledge to the students for analyzing the data/results.
4	To deliver know-how of typical optimization techniques applicable to engineering problems.

Course Outcomes (CO) with Bloom's Taxonomy Level		
CO1	***Solve*** linear, nonlinear equations, ODE and PDE by numerical methods.	Apply
CO2	***Analyze*** data using various methods of regression and interpolation.	Analyse
CO3	***Propose*** optimal solution using appropriate techniques.	Create

Module	Module Contents	Hours
I	**Introduction to Optimization Techniques** Introduction O. R., Problem Formulation, Classification of optimization problems. Unconstrained optimization, constrained optimization, Optimization of Linear P. P. Using Simplex method, Duality and sensitivity analysis.	6
II	**Optimization Problems and Solutions** Typical optimization problems in engineering and their solutions such as Assignment Problem, Transportation Problem, Shortest path, Minimal Spanning tree, Maximum flow Problem.	**7**
III	**Dynamic Programming** Dynamic Programming: Multistage decision process, recursive relationships, Principle of optimality, Computational procedure in DP, DP applications, Problem of dimensionality. Game theory, Introduction to genetic algorithm and Simulation.	7

IV	**Introduction to Computational Methods** Introduction to Computational Methods, Accuracy & Precision, Error in Computational Methods, Significance of error computation. Revision of computational methods for solving linear and non-linear equations, Gauss Seidel Method, one point iteration method, Multiple Roots, Polynomial equations, Descartes' rule, Strum theorem.	6
V	**Interpolation and Regression Methods** Difference between regression and interpolation, Linear interpolation, quadratic interpolation, General form of Newton's Interpolating Polynomial, Newton's divided difference interpolation polynomials, Lagrange's Interpolating Polynomials. Linear Regression, Least Squares Method, Polynomial Regression, Nonlinear Regression: Power fit, Parabola of Best fit.	6
VI	**Numerical Differentiation and Integration** Numerical Differentiation and integration, Numerical Quadrature, Cote's formula, Difference Equations, Solutions of Ordinary Differential Equations, Initial value and boundary value problems, Classification of methods of solution. Runge-Kutta Method, Solutions of B.V. Problems by Finite Difference methods. Classification of Partial Differential Equations, Formation of difference equations, Solution of Laplace's and Poisson's equations.	8

Text Books	
1	Chapra S.C. and Canale R.P., "Numerical Methods for Engineers", Tata McGraw Hill Publications, 4th Edition, 2002.
2	Babu Ram "Numerical Methods", Pearson, 1st Edition, 2010.
3	Hamdy A. Taha, "Introduction to O.R.", 6th edition, (PHI)

References	
1	Balguruswamy, E. "Numerical Methods", Tata McGraw-Hill Publishing Co. Ltd., 2nd Edition, 2009.
2	Jain M.K., Iyengar S. R., Jain R. K., "Numerical Methods", New Age International (P) limited,5th Edition, 2007.
3	N.D. Vora, "Quantitative Techniques in Management", 2nd edition (TMH).

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			3			
CO2				3		
CO3				3		

Assessment
The assessment is based on 2 Tests (T1 & T2) of 20 marks each, and 1 end-semester examination (ESE) of 60 marks. Test 1 is typically based on the modules 1 & 2. Test 2 is based on modules 3 & 4 and ESE is based on all modules with 40-50% weightage on modules 1 to 4 and 50-60% weightage on modules 5 & 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand				
Apply	10	10	25	**45**
Analyze	10	10	20	**40**
Evaluate				
Create			15	**15**
Total	**20**	**20**	**60**	**100**

Walchand College of Engineering, Sangli

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Course Information

Programme	M. Tech Civil (Environmental Engineering)
Class, Semester	First Year M. Tech., Semester I
Course Code	5EV513
Course Name	Water Quality Modeling
Desired Requisites:	Basics of hydraulics and water quality

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs./week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 3**			

Course Objectives

1	Impart in-depth knowledge of modelling /simulation of water quality in surface, and sub-surface sources.
2	Enhance technical competency to deal with water quality issues in real life cases through modeling.

Course Outcomes (CO) with Bloom's Taxonomy Level

CO1	***Explain*** and ***apply*** concepts of simulation/modeling for pollutant transport in surface and sub-surface sources of water.	Understanding Applying
CO2	***Analyze*** and ***evaluate*** the processes contributing to water quality variations.	Analyzing Evaluating
CO3	***Apply*** the modern tools of engineering for the analysis and design of environmental systems.	Applying

Module	**Module Contents**	**Hours**
I	**Fundamentals of Water Quality Modeling** Fundamentals: Concept of modeling, Model development, Types of models, Model sensitivity, Assessment of model performance, Movement of the contaminants in the environment Water quality in distribution system, Causes of variation, transport of constituents in pipe, chemical reactions, water quality simulations for source trace and water age.	6
II	**Streams/Rivers and Estuaries** Streams/Rivers and Estuaries: Dispersion and Mixing of pollutants, Estuary transport, Point and non-point/distributed sources of pollution, Application plug and mixed flow reactors (MFR) to streams with point and distributed sources, Spill models for plug and mixed flow system, Application of MFR model to estuaries.	6
III	**Process of Water Quality Modeling** Water quality modeling process, Modeling of organic pollution of stream, Streeter-Phelps equation for point, multiple point and distributed sources, Calibration, Modified/Total Streeter-Phelps equation, Anaerobic condition, Estuary Streeter-Phelps equation.	8

IV	**Groundwater Pollution and Control** Sources of groundwater pollution, Groundwater movement, Cone of Depression, Capture zone curve, Immiscible compounds, Processes in solute migration through porous media, Solute transport equation, Chemical reaction during transport, Sorption and retardation, Dupuit - Forchheimer theory of free surface flow, Control measures for contaminant plume, Hydrodynamic, physical, conventional pump and treat system, Soil vapour extraction with and without air sparging, In-situ bioremediation.	8
V	**Lakes and Rivers** Eutrophication problem in lakes and flowing water, Role of Carbon, Nitrogen and phosphorous, Phosphorous loading concept, Thermal stratification, Stratification and dissolved oxygen, Hydraulic behaviour of lakes, Effects of physical processes on water quality, Modeling of lakes and reservoirs.	7
VI	**Introduction to Water Quality Modeling Software** Study of modeling with EPANET, Qual2e and MODFLOW: Model conceptual basis, Modeling environment, Capabilities, Applications.	5

Text Books	
1	Tchobanoglous G. and Schroeder E. D., "Water Quality: Characteristics, Modeling and Modifications", Addison-Wesley publishing company, Reprint 1987.
2	Chapra S., "Surface Water Quality Modeling", Tata Mc-Graw Hill, 1997.
3	Walski, Chase and Savic, "Water Distribution Modeling", Haestad Press, First edition, 2007.

References	
1	Lee C. C and Lin S. D., "Hand book of environmental engineering calculations", McGraw Hill Publication, 2nd Edition 2007.
2	Todd D. K., "Groundwater Hydrology", John Wiley & Sons, Second Edition, 2007.
3	Metcalf and Eddy, "Wastewater Engineering Treatment and Reuse", Tata McGraw Hill Publication, 6th Reprint. 2003.

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			3			
CO2						3
CO3			3			

Assessment
The assessment is based on 2 Tests (T1 & T2) of 20 marks each, and 1 end-semester examination (ESE) of 60 marks. Test 1 is typically based on the modules 1 & 2. Test 2 is based on modules 3 & 4 and ESE is based on all modules with 40-50% weightage on modules 1 to 4 and 50-60% weightage on modules 5 & 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand	5	5	15	**25**
Apply	10	5	20	**35**
Analyze	5	5	15	**25**
Evaluate		5	10	**15**
Create				
Total	**20**	**20**	**60**	**100**

Walchand College of Engineering, Sangli

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AY 2021-22

Course Information	
Programme	M. Tech. Civil (Environmental Engineering)
Class, Semester	First Year M. Tech., Semester I
Course Code	5EV501
Course Name	Physico-Chemical Methods for Water and Wastewater Treatment
Desired Requisites:	A course on Environmental Engineering at graduate level

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs./week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 3**			

Course Objectives	
1	To provide in-depth knowledge of unit operations and processes for the treatment of water and wastewater.
2	To impart technical competency for analysis, evaluation and design of physical and chemical treatment systems for water and wastewater.
3	To inculcate aptitude for research, and consultancy.

Course Outcomes (CO) with Bloom's Taxonomy Level		
CO1	***Explain*** and ***Apply*** the concepts of unit operations and processes for physical and chemical treatment of water and wastewater.	Understand Apply
CO2	***Analyse*** and ***evaluate*** the physical and chemical treatment systems used in water and wastewater.	Analyze Evaluate
CO3	***Design*** physical and chemical treatment systems for water and wastewater.	Create

Module	**Module Contents**	**Hours**
I	**Transport Phenomena and Reaction Kinetics** Review of conventional unit operations and processes in water and wastewater treatment, Transport processes, Kinetics and Reaction rates, System material balance, Hydraulic transport flow regimes, Reactor Engineering (CMBR, CMFR, CMFRS, PFR, PFRD), Processes and rates of gas transfer	7
II	**Aeration and Mixing** Types of aerator, Design of gravity aerators Coagulation and flocculation, Stability and destabilization of colloids, Transport of colloidal particles, Design of rapid and slow mix units Types of settling, Design of sedimentation tanks, Tube settler, Grit chamber (horizontal flow and aerated)	8
III	**Filtration** Gravity and pressure filtration, filter hydraulics, Analysis of filtration process, Backwash hydraulics, Rate control patterns and methods, Design of dual media and pressure filter	5
IV	**Adsorption and Ion Exchange** Causes and Types of adsorption, Adsorption equilibria and adsorption isotherm, Process, Analysis and design of batch and continuous flow activated carbon absorber Ion Exchange process, Exchange materials and capacity, Exchange reactions, Design and operation of softener for hardness and TDS removal	8

V	**Membrane Filtration** Membrane separation processes, Design and operation of Reverse osmosis, Ultrafiltration, and Electrodialysis. Membrane fouling: Causes, and Control.	7
VI	**Disinfection** Kinetics of disinfection Ozone disinfection: Chemistry, System components, Modelling. UV disinfection: Source, System components, Estimation of UV dose. Principles and theories of Chemical oxidation.	5

Text Books	
1	Peavy H, S, Rowe D, R, and Tchobanoglous G, "Environmental Engineering", McGraw-Hill Book Company, Indian edition 2017.
2	Metcalf and Eddy "Wastewater Engineering Treatment and Reuse", Tata McGraw Hill Publication, Indian Edition 2017.
3	Davis, M, L, and Cornwell, D, A, "Introduction to Environmental Engineering", Tata McGraw Hill Publishing Company, Special Indian Edition, 2010.
4	Unit Operations and Processes in Environmental Engineering, 2nd Edition, by Tom D. Reynolds and Paul A. Richards, PWS Publishing Company, 1995.

References	
1	Droste, Ronald L "Theory and Practice of Water and Wastewater Treatment", Wiley student Edition, 2009.
2	Weber W, J, "Physico-Chemical Processes of Water quality control", Wiley-Interscience, 1994.
3	Sincero A, P and Sincero G, A, "Environmental Engineering A Design approach", PHI learning private limited, 2004.
4	Quasim, S. R., Motley E, M and Zhu G, "Water works engineering", PHI learning private limited, 2000.

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			3			
CO2				3		
CO3						3

Assessment
The assessment is based on 2 Tests (T1 & T2) of 20 marks each, and 1 end-semester examination (ESE) of 60 marks. Test 1 is typically based on the modules 1 & 2. Test 2 is based on modules 3 & 4 and ESE is based on all modules with 40-50% weightage on modules 1 to 4 and 50-60% weightage on modules 5 & 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand	5		15	**20**
Apply	10	5	10	**25**
Analyze	5	5	10	**20**
Evaluate		5	10	**15**
Create		5	15	**20**
Total	**20**	**20**	**60**	**100**

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AY 2021-22

Course Information	
Programme	M. Tech. Civil (Environmental Engineering)
Class, Semester	First Year M. Tech., Semester II
Course Code	5EV522
Course Name	Air Pollution and Control
Desired Requisites	A graduate level course in Environmental Engineering

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs./week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 3**			

Course Objectives	
1	To provide knowledge on physics of atmosphere, meteorology and its relation to air pollution, different types of air pollution control equipment.

Course Outcomes (CO) with Bloom's Taxonomy Level		
CO1	***Recognize*** and ***summarize*** scientific and engineering principles for air pollution studies	Remember Understand
CO2	***Apply*** appropriate dispersion models ***estimate*** air pollutant concentrations	Apply Evaluate
CO3	***Analyze*** situations leading to air pollution and ***design*** air pollution control strategies with due consideration to technical, environmental, health, safety and social considerations	Analyze Evaluate

Module	**Module Contents**	**Hours**
I	**Air pollution: A retrospective** Air pollution: sources and types and effects on biosphere, National and international air emission standards; air pollution emission inventory; emission factor; air quality index; Strategy for effective control of air pollution in India, Introduction to air pollution control act, and international agreements for mitigating global air pollution effects.	7
II	**Meteorology** Physics of atmosphere, Solar radiation, Wind circulation, Lapse rate, Inversion, Stability conditions, Pasquil stability model, Maximum mixing depth, Wind rose, Plume behaviour, Global effects of air pollution: Green house effects, acid rain and ozone layer depletion, Heat island effect, Visibility, Photochemical reaction	7
III	**Dispersion of pollutants in the atmosphere** Eddy diffusion model, the Gaussian dispersion model, Point source, Line source, Maximum ground level concentration, Determination of stack height, Sampling time corrections, Effects of inversion trap Definition, Distribution and source of different particulate matter, Terminal settling velocity, Basics of hood and duct design for particulate collection	6

IV	**Control Equipment for Particulate Matter** Operation design and component detailing of Settling chamber, Cyclone, Wet collectors, Fabric filter, and Electrostatic precipitator	7
V	**General control of Gaseous pollutants** Principles of absorption, Adsorption, Basic design of absorption and adsorption units, Incineration and after burner, Control of SO_2, NOx.	7
VI	**Motor Vehicle Emissions** Automobile Source Emission of pollutants from automobiles, Photochemical smog, Reduction of emissions by different methods, Alternative fuels and their utilizations	6

Text Books	
1	Wark and Warner, "Air Pollution", C.F., H.R. Publication, 1st Edition, 1978.
2	Nevers N., "Air Pollution Control Engineering" McGraw-Hill, New York, 2nd edition, 1995.
3	Martin Crawford, "Air Pollution and Control", Tata McGraw Hill Publication, 1st Edition, 1976.

References	
1	Richard W. Boubel and Bruce Turner, "Fundamentals of Air Pollution", Academic Press, New York, Third edition, 1994.
2	Stern A. C., "Air Pollution Vol. I and II", Allied Publishers Limited, 1 st Edition, 1994.
3	Rao H.V.N. and Rao M. N., "Air Pollution", Tata McGraw Hill, 1st Edition, 1989.

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			3			
CO2			3			3
CO3				3		3

Assessment
The assessment is based on 2 Tests (T1 & T2) of 20 marks each, and 1 end-semester examination (ESE) of 60 marks. Test 1 is typically based on the modules 1 & 2. Test 2 is based on modules 3 & 4 and ESE is based on all modules with 40-50% weightage on modules 1 to 4 and 50-60% weightage on modules 5 & 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember	5	5	10	**20**
Understand	5	5	15	**25**
Apply	10	5	15	**35**
Analyze		5	10	**15**
Evaluate			10	**10**
Create				
Total	**20**	**20**	**60**	**100**

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AY 2021-22

Course Information

Programme	M. Tech. Civil (Environmental Engineering)
Class, Semester	First Year M. Tech., Semester II
Course Code	5EV521
Course Name	Biological Methods for Wastewater Treatment
Desired Requisites:	A course on Wastewater Treatment at graduate level and Physico-Chemical Methods for Water and Wastewater Treatment

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	3 Hrs./week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 3**			

Course Objectives

1	To provide conceptual and field knowledge for the analysis, design and evaluation of biological processes of wastewater treatment.
2	To enhance the technical competency to conduct research and address the problems of industry/society related to wastewater treatment.
3	To inculcate the qualities of critical thinking.

Course Outcomes (CO) with Bloom's Taxonomy Level

CO1	***Explain*** and ***Apply*** the acquired knowledge on biological wastewater treatment.	Understanding Applying
CO2	***Analyse*** and ***evaluate*** the suspended and attached growth, aerobic and anaerobic biological wastewater treatment systems at secondary and tertiary levels.	Analyzing Evaluating
CO3	***Design*** wastewater treatment and sludge processing facilities.	Creating

Module	**Module Contents**	**Hours**
I	**Biochemical Processes** Fundamentals: Measurement of organic pollutant, Biochemical transformation, Bioreactor configuration, Aerobic, Anoxic and Anaerobic Biochemical operations Kinetics of Bio-chemical operations: Biomass growth, Substrate utilization, Yield Kinetics of (Aerobic/Anoxic, Anaerobic) biomass growth	6
II	**Suspended and Attached Growth Systems for Carbon Oxidation** Review of conventional activated sludge process (ASP), aerated lagoon and waste stabilization ponds Modeling aerobic suspended growth in complete-mix and plug flow reactor with and without recycle Design and operation of sequential batch/cyclic ASP and membrane bioreactor Biological filtration, Eckenfelder model for performance of packed tower with and without recirculation Design and operation of rotating biological contactor	9

III	**Biological Nitrogen and Phosphorous Removal** Biological nitrogen and phosphorous removal, Kinetics of nitrification and denitrification Process design of ASP, SBR and RBC for carbon oxidation – nitrification and denitrification	5
IV	**Sludge Processing** Design and operation of Upflow Anaerobic Sludge Blanket system Sludge processing: Sludge mass-volume relationship, Process fundamentals of Thickening, Stabilization, Conditioning, and Dewatering Design and operation of gravity thickener, dissolved air flotation tank, anaerobic digester, belt press and sludge drying bed	9
V	**Onsite Treatment and Constructed Wetland** Design and operation of decentralized wastewater treatment systems Moving Bed Bio reactor, Anaerobic filter, Modified septic tank Constructed Wetland (CW): Classification and application, Design and operation of horizontal flow subsurface, Vertical flow systems Emerging concepts in CW, Sludge treatment constructed wetland Design and operation of Water hyacinth system	7
VI	**Land Treatment Processes** Land treatment systems: Processes, Removal mechanisms, Design and operation of slow rate, rapid infiltration and overland flow systems	4

Text Books	
1	Peavy H, S, Rowe D, R, and Tchobanoglous G, "Environmental Engineering", McGraw-Hill Book Company, Indian edition 2017.
2	Metcalf and Eddy "Wastewater Engineering Treatment and Reuse", Tata McGraw Hill Publication, Indian Edition 2017.
3	Unit Operations and Processes in Environmental Engineering, 2nd Edition, by Tom D. Reynolds and Paul A. Richards, PWS Publishing Company, 1995.

References	
1	Droste, Ronald L "Theory and Practice of Water and Wastewater Treatment", Wiley student Edition, 2009.
2	Crites Ron and Tchobanoglous George, "*Small and Decentralized Wastewater Management Systems*", McGraw-Hill Book Company, International edition, 1998.
3	Sincero A, P and Sincero G, A, *"Environmental Engineering A Design approach",* PHI learning private limited, 2004.
4	Quasim, S. R., "Wastewater treatment plants planning, design and operation", CRC Press, 2nd Edition, 2010.

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			3			
CO2				3		
CO3						3

Assessment
The assessment is based on 2 Tests (T1 & T2) of 20 marks each, and 1 end-semester examination (ESE) of 60 marks. Test 1 is typically based on the modules 1 & 2. Test 2 is based on modules 3 & 4 and ESE is based on all modules with 40-50% weightage on modules 1 to 4 and 50-60% weightage on modules 5 & 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand	5		10	**15**
Apply	10	5	10	**25**
Analyze	5	5	10	**20**
Evaluate		5	10	**15**
Create		5	20	**25**
Total	**20**	**20**	**60**	**100**

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Course Information

Programme	M. Tech. Civil (Environmental Engineering)
Class, Semester	First Year M. Tech., Semester II
Course Code	5EV571
Course Name	Activity Based Lab: Biological Methods for Wastewater Treatment
Desired Requisites	Physico-Chemical Methods for Water and Wastewater Treatment and Biological Methods for Wastewater Treatment

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	-	**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2				
Interaction	-	**Credits: 1**			

Course Objectives

1	To provide exposure to work on the real-life problems.
2	To provide an opportunity to contribute individually to the development of experimental set ups by applying the acquired technological knowledge.

Course Outcomes (CO) with Bloom's Taxonomy Level

CO1	Design experiments by applying the acquired knowledge on techniques and tools.	Create
CO2	Carry out experimental studies for characterization, parameter estimation, and performance evaluation independently and in teams.	Apply
CO3	Analyze, critique, and interpret experimental results through application of modern engineering tools and conclude based on the results.	Analyze Evaluate

List of project works

One from each group by each student

Group A (Laboratory based)

1. Development of activated sludge based reactor and assess its performance.
2. Determination of bio-kinetic coefficients.
3. Study on sludge thickening and dewatering.
4. Development of anaerobic reactor and assess its performance.
5. Oxygen transfer rate of diffused aerator.

Group B (Real-life system)

1. Design of decentralized wastewater treatment system for a colony/public building/institution/apartment.
2. Performance of real-life sewage treatment plant for BOD removal.
3. Design of package wastewater treatment system for household application.
4. Effect of sewage disposal on land/groundwater.

Text Books

1	Hammer M, J and Hammer M, J, "Water and Wastewater Technology", PHI learning private limited, 6th Edition, 2008.

2	Metcalf and Eddy "Wastewater Engineering Treatment and Reuse", Tata McGraw Hill Publication, 6th Reprint. 2003.
3	Lee C, C and Lin S, D, "Hand book of environmental engineering calculations", McGraw Hill Publication, 2nd Edition. 2007.
References	
1	Sawyer and McCarty, "Chemistry for Environmental Engineers", Tata McGraw Hill, Edition 5, 2003.
2	Clesceri, L. S., Greenberg, A. E. and Eaton, A. D. (Eds), Standard Methods for the Examination of Water and Wastewater, Washington, D.C., 21st Ed., 2001.
3	Quasim, S. R., "Wastewater treatment plants planning, design and operation", CRC Press, 2nd Edition, 2010.

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			3			
CO2				3		

Assessment				
There are three components of lab assessment, LA1, LA2 and ESE				
Assessment	**Based on**	**Conducted by**	**Typical Schedule**	**Marks**
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 5 Marks Submission at the end of Week 5	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 6 to Week 10 Marks Submission at the end of Week 9	30
ESE	Lab Performance and documentation	Lab Course Faculty	During Week 10 to Week 15 Marks Submission at the end of Week 15	40
Week 1 indicates starting week of Semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.				

Bloom's Taxonomy Level	**LA1**	**LA2**	**ESE**	**Total**
Remember				
Understand				
Apply	10	10	10	**30**
Analyze	10	10	10	**30**
Evaluate		10	10	**20**
Create	10		10	**20**
Total	**30**	**30**	**40**	**100**

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Course Information

Programme	M. Tech. Civil (Environmental Engineering)
Class, Semester	First Year M. Tech., Semester II
Course Code	5EV572
Course Name	Activity Based Lab: Air Pollution and Control
Desired Requisites:	Air Pollution and Control

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	-	**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2				
Interaction	-	**Credits: 1**			

Course Objectives

1	To provide hands on practice to analyze quality of ambient air, noise levels and stack emissions
2	To provide knowledge to analyze environmental condition

Course Outcomes (CO) with Bloom's Taxonomy Level

CO1	***Recognize*** and ***explain*** use of instrumentation for air and noise monitoring	Remember Understand
CO2	***Use*** instrumentation for air and noise monitoring	Apply
CO3	***Examine*** the results obtained through experimentation and ***Assess*** the prevailing environmental condition	Analyze Evaluate

List of Experiments / Lab Activities

At least four from group A

Group A (Laboratory based):

1. Study of air samplers for ambient air quality monitoring
2. Study of air samplers for indoor air quality monitoring
3. Study of stack monitoring kit
4. Study of automobile exhaust analyzer
5. Study of weather monitoring station
6. Study of noise level meter

At least 1 from group B

Group B (Real life system):

1. Indoor/Outdoor air quality monitoring of enclosed/open area
2. Stack monitoring of industrial stack
3. Ambient noise level monitoring of institutions like college/hospital/government offices etc.

Text Books

1	Wayne T. D., Air Pollution Engineering Manual, John Wiley & Sons, 2000.
2	Rao C. S., Environmental Pollution Control Engineering, New Age Int. Pubs, 2005.
3	Nevers N., "Air Pollution Control Engineering" McGraw-Hill, New York, 2nd edition, 1995.

References

1	Sincero A. P. and Sincero G, A, "Environmental Engineering A Design approach", PHI learning Private limited, 2004.
2	Nathanson J. A. "Basic Environmental technology for water supply, waste management and Pollution control", PHI Publishing Company, 5th Edition, 2009.
3	Wark K. and Warner C.F., "Air Pollution", C.F., H.R. Publication, 1st Edition, 1978.

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			2	3		
CO2				3		2
CO3				3		2

Assessment				
There are three components of lab assessment, LA1, LA2 and ESE				
Assessment	**Based on**	**Conducted by**	**Typical Schedule**	**Marks**
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 5 Marks Submission at the end of Week 5	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 6 to Week 10 Marks Submission at the end of Week 9	30
ESE	Lab Performance and documentation	Lab Course Faculty	During Week 10 to Week 15 Marks Submission at the end of Week 15	40
Week 1 indicates starting week of Semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.				

Bloom's Taxonomy Level	**LA1**	**LA2**	**ESE**	**Total**
Remember	10		5	**15**
Understand	10		5	**15**
Apply	10	10	10	**30**
Analyze		10	10	**20**
Evaluate		10	10	**20**
Create				
Total	**30**	**30**	**40**	**100**

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Course Information

Programme	M. Tech. Civil (Environmental Engineering)
Class, Semester	First Year M. Tech., Semester II
Course Code	5EV575
Course Name	Activity Based Lab: Environmental Chemistry
Desired Requisites:	Engineering Chemistry

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	-	**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2				
Interaction	-	**Credits: 1**			

Course Objectives

1	To provide hands-on practice for analyzing the water and wastewater by physical, chemical and instrumental methods.
2	To provide fundamental knowledge of laboratory skills.
3	To impart knowledge of microbiology and bacterial identification.

Course Outcomes (CO) with Bloom's Taxonomy Level

CO1	***Experiment*** water/wastewater quality analysis through physical, chemical, biological and advanced instrumental methods.	Apply
CO2	***Analyse*** and ***interpret*** data acquired from the experiments.	Apply Analyze
CO3	***Evaluate*** the quality of WTP/STP/ETP effluent	Evaluate

List of Experiments / Lab Activities

Group A (Laboratory Based)

Instrumental Methods:

Study and use of

a. Flame photometer
b. Spectrophotometer
c. TOC Analyzer
d. Gas Chromatograph
e. Atomic Absorption Spectrophotometer
f. Zeta meter
g. CHNS Analyzer

Group B (Real life Project)

a. Performance evaluation of Water Treatment Plant (WTP)/ Sewage Treatment Plant (STP)/ Effluent Treatment Plant (ETP) by collecting water/wastewater samples before and after treatment. Following tests may be performed for water/wastewater quality analysis: pH, Acidity and Alkalinity, Electrical conductivity, Solids, Hardness, Dissolved oxygen, Chloride content, Residual chlorine in water, Dissolved organic matter by BOD and COD, Nitrate, Sulphate, Fluoride, Iron and Manganese and Most Probable Number (MPN)

Text Books	
1	Peavy H. S., Rowe D. R. and Tchobanoglous G, "Environmental Engineering", McGraw-Hill book company, 1st Edition, 2013.
2	Sawyer C.N. and McCarty P. L., "Chemistry for Environmental Engineers", Tata McGraw-Hill Publishing Company Limited, 5th Edition, 2003.
References	
1	American Public Health Association (APHA), "Standard Methods for the Examination of Water and Wastewater", 23rd Edition, 2017.
2	Metcalf and Eddy "Wastewater Engineering Treatment and Reuse", Tata McGraw Hill Publication, 6th Reprint. 2003.
Useful Links	
1	https://www.youtube.com/channel/UCXOTUs9n8uhzYzBC8NHeacA

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			2	3		
CO2			2	2		
CO3			2	1		

Assessment				
There are three components of lab assessment, LA1, LA2 and ESE				
Assessment	**Based on**	**Conducted by**	**Typical Schedule**	**Marks**
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 5 Marks Submission at the end of Week 5	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 6 to Week 10 Marks Submission at the end of Week 9	30
ESE	Lab Performance and documentation	Lab Course Faculty	During Week 10 to Week 15 Marks Submission at the end of Week 15	40
Week 1 indicates starting week of Semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.				

Bloom's Taxonomy Level	LA1	LA2	ESE	Total
Remember				
Understand				
Apply	10	10	15	**35**
Analyze	10	10	15	**35**
Evaluate	10	10	10	**30**
Create				
Total	**30**	**30**	**40**	**100**

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Course Information

Programme	M. Tech. Civil (Environmental Engineering)
Class, Semester	First Year M. Tech., Semester II
Course Code	5EV576
Course Name	Activity Based Lab: Hazardous Waste Management
Desired Requisites:	Hazardous Waste Management

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	-	**LA1**	**LA2**	**ESE**	**Total**
Tutorial	-	30	30	40	100
Practical	2				
Interaction	-	**Credits: 1**			

Course Objectives

1	Provide in-depth knowledge of hazardous waste management.
2	To enhance the technical competency and apply the acquired knowledge for research and development, industry, and consultancy activities.

Course Outcomes (CO) with Bloom's Taxonomy Level

CO1	***Explain*** characterization, waste minimization, transportation, site remediation, and risk associated with hazardous waste.	Understand
CO2	***Explain*** and ***apply*** the physical, chemical, and biological methods of treating hazardous waste.	Understand Apply
CO3	***Design*** treatment and disposal facilities for hazardous waste.	Create

List of Experiments / Lab Activities

Minimum two activities out of following should be completed

a. A presentation and report on hazardous waste management case study.

b. A visit to hazardous waste management plant (e.g. biomedical waste processing plant, CETP sludge disposal landfill etc.) should be done and individual site visit report should be prepared.

c. A visit to chemical laboratory working in hazardous waste testing should be done and a report on methods used for hazardous waste analysis should be prepared.

Text Books

1	LaGrega, M. D., Buckingham, P. L. and Evans, J. C., Hazardous Waste Management, 2nd Edition, McGraw Hill, 2001.
2	Metcalf and Eddy "Wastewater Engineering Treatment and Reuse", Tata McGraw Hill Publication, 6th Reprint, 2003.
3	LaGrega, M. D., Buckingham, P. L. and Evans, J. C., Hazardous Waste Management, 2nd Edition, McGraw Hill, 2001.

References

1	Sincero A, P and Sincero G, A, "Environmental Engineering A Design approach", PHI learning private limited, 2004.
2	Wentz, C. A., Hazardous Waste Management, 2nd Ed., McGraw Hill, 1995.

3	Lewandowski G.A. and DeFilippi L.J., Biological Treatment of Hazardous Wastes, John Wiley & Sons, 1998.
Useful Links	
1	https://www.youtube.com/watch?v=prsVIHDDCyM
2	https://www.youtube.com/watch?v=Awiq0JLfmMA

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			2	3		
CO2			2	2		
CO3			2	1		

Assessment				
There are three components of lab assessment, LA1, LA2 and ESE				
Assessment	**Based on**	**Conducted by**	**Typical Schedule**	**Marks**
LA1	Lab activities, attendance, journal	Lab Course Faculty	During Week 1 to Week 5 Marks Submission at the end of Week 5	30
LA2	Lab activities, attendance, journal	Lab Course Faculty	During Week 6 to Week 10 Marks Submission at the end of Week 9	30
ESE	Lab Performance and documentation	Lab Course Faculty	During Week 10 to Week 15 Marks Submission at the end of Week 15	40
Week 1 indicates starting week of Semester. Lab activities/Lab performance shall include performing experiments, mini-project, presentations, drawings, programming and other suitable activities, as per the nature and requirement of the lab course. The experimental lab shall have typically 8-10 experiments.				

Bloom's Taxonomy Level	**LA1**	**LA2**	**ESE**	**Total**
Remember				
Understand	10	10	15	**35**
Apply	10	10	15	**35**
Analyze				
Evaluate				
Create	10	10	10	**30**
Total	**30**	**30**	**40**	**100**

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Course Information

Programme	M. Tech. Civil (Environmental Engineering)
Class, Semester	First Year M. Tech., Semester II
Course Code	5EV523
Course Name	Environmental Chemistry and Microbiology
Desired Requisites:	A course on chemistry at graduate level

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	2 Hrs./week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 2**			

Course Objectives

1	To provide in-depth knowledge of environmental chemistry and microbiology for the treatment of water, wastewater and solid waste.

Course Outcomes (CO) with Bloom's Taxonomy Level

CO1	***Explain*** the basic concepts of environmental chemistry and microbiology of water and wastewater.	Understand
CO2	***Summarize*** environmental significance of organic compounds and microorganisms.	Understand
CO3	***Apply*** instrumental and microbiological methods for water and wastewater analysis.	Apply

Module	**Module Contents**	**Hours**
I	**Introduction to General Chemistry and Physical Chemistry** **General chemistry:** Nomenclature, Valency, Oxidation-reduction equations, Ionization, Solubility Product, Common ion effect. **Physical chemistry:** Enthalpy, Entropy, Vapour pressure	5
II	**Introduction to Organic Chemistry** **Organic chemistry:** Environmental significance of different organic compounds viz. Aliphatic Compounds: Alcohols, Aldehydes and Ketones, Acids, Esters, Ethers, Halogenated aliphatic compounds, Compounds containing nitrogen. Aromatic Compounds: Hydrocarbons, Phenols, Alcohols, Aldehydes, Ketones and Acids, Compounds containing nitrogen, Heterocyclic compounds, Dyes, Detergents and Pesticides.	3
III	**Instrumental Methods** **Instrumental Methods:** UV- visible, atomic absorption spectroscopy, flame photometry with reference to principle, instrumentation, calibration, working and applications in environmental analysis. Chromatography and its types. Mass spectroscopy and Gas chromatography with reference to principle, instrumentation, calibration, working and applications in environmental analysis.	8

IV	**Introduction to Biochemistry** Biochemistry of carbohydrates and Proteins, General biochemical pathways.	3
V	**Introduction to Environmental Microbiology** Groups of microorganisms, Major characteristics of microorganisms, Microbial classification, nomenclature and identification, Cell elements and composition, Cell and its composition, Cytoplasmic membrane, Prokaryotic cell division, Growth curve of bacteria, Enzymes and their regulation, Control of microorganisms by physical and chemical agents.	5
VI	**Water, Wastewater and Solid Waste Treatment using Microbiome** Drinking water microbiology, Drinking water microbiome and treatment Bioremediation and wastewater microbiology, Bioremediation examples, Enhanced metal recovery. Solid waste microbiology, Landfills, Leachate anaerobic degradation phases.	4

Text Books	
1	Sawyer C.N. and McCarty P.L., "Chemistry for Environmental Engineers", Tata McGraw-Hill Publishing Company Limited, 5th Edition, 2003.
2	Holler F. J. and Crouch S. R., "Skoog and West's Fundamentals of analytical Chemistry", Cengage Learning, 9th Edition, 2012.
3	Mohapatra P. K., "Textbook of Environmental Microbiology", I. K. International Publishing House Pvt. Ltd., Reprint 2013.

References	
1	VanLoon G. W. and Duffy S. J., "Environmental Chemistry: A Global Perspective", Oxford University Press, Indian Edition, Reprint 2011.
2	Pelczar Jr., M. J. E. C. S. Krieg, R. Noel., and Pelczar M. F., "Microbiology", Tata McGraw Hill Publishing Company Limited, Reprint 2012.
3	Madigan, M., Bender K. S., Buckley D.H., Sattley W. M., and Stahl D.A., "Brock Biology of Microorganisms", 15th Edition New York: Pearson, 2017.

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			2			
CO2			2			
CO3			3	1		1

Assessment

The assessment is based on 2 Tests (T1 & T2) of 20 marks each, and 1 end-semester examination (ESE) of 60 marks.

Test 1 is typically based on the modules 1 & 2. Test 2 is based on modules 3 & 4 and ESE is based on all modules with 40-50% weightage on modules 1 to 4 and 50-60% weightage on modules 5 & 6.

Bloom's Taxonomy Level	**LA1**	**LA2**	**ESE**	**Total**
Remember				
Understand				
Apply	15	15	20	**50**
Analyze	15	15	20	**50**

Evaluate				
Create				
Total	**30**	**30**	**40**	**100**

Walchand College of Engineering, Sangli *(Government Aided Autonomous Institute)*					
AY 2021-22					
Course Information					
Programme	M. Tech. Civil (Environmental Engineering)				
Class, Semester	First Year M. Tech., Semester II				
Course Code	5EV524				
Course Name	Hazardous Waste Management				
Desired Requisites:	Wastewater and Industrial Waste treatment				
Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	2 Hrs./week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 2**			

Course Objectives	
1	Provide in-depth knowledge of hazardous waste management.
2	To enhance the technical competency and apply the acquired knowledge for research and development, industry, and consultancy activities.

Course Outcomes (CO) with Bloom's Taxonomy Level		
CO1	***Explain*** characterization, waste minimization, transportation, site remediation, and risk associated with hazardous waste.	Understand
CO2	***Explain*** and ***apply*** the physical, chemical, and biological methods of treating hazardous waste.	Understand Apply
CO3	***Design*** treatment and disposal facilities for hazardous waste.	Create

Module	**Module Contents**	**Hours**
I	**Introduction to hazardous Waste Management** Hazardous waste: Definition, Sources, Characterization, Classification, Magnitude of problem, Concept of toxicity, Assessment of sites.	4
II	**Waste minimization and Treatment** Waste minimization: Benefits, Approaches, Priorities in hazardous waste management, Resources recovery, Case studies. Treatment: Physical, Chemical and Biological treatment systems applicable for hazardous waste, Hazard in processing, Case studies of treatment.	5
III	**Transportation of Hazardous Waste** Transportation: Storage of hazardous waste, Regulations governing transporters, Containers, Bulk transport, Non-bulk transport, Hazardous substances emergency response.	5
IV	**Disposal of Hazardous Waste** Land fill disposal: Land fill as disposal sites, Siting, Designing, Closure, Case studies Injection well disposal: Classifications, Deep well injection, Case studies.	5

V	**Site Remediation** Site remediation: Site assessment and inspection, Hazard ranking system, Containment and treatment technologies, financial considerations, Case studies.	5
VI	**Risk Assessment** Risk Assessment: Process, Risk management, Hazardous waste management rules.	4

Text Books	
1	LaGrega, M. D., Buckingham, P. L. and Evans, J. C., Hazardous Waste Management, 2nd Edition, McGraw Hill, 2001.
2	Metcalf and Eddy "Wastewater Engineering Treatment and Reuse", Tata McGraw Hill Publication, 6th Reprint, 2003.
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Useful Links	
1	https://www.youtube.com/watch?v=x8ViYoqjEhc&t=4s
2	https://www.youtube.com/watch?v=prsVIHDDCyM
3	https://www.youtube.com/watch?v=Awiq0JLfmMA

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			3			
CO2				3		
CO3						3

Assessment
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Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand	10	5	20	**35**
Apply	10		20	**30**
Analyze		10		**10**
Evaluate				
Create		5	20	**25**
Total	**20**	**20**	**60**	**100**

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Course Information	
Programme	M. Tech. Civil (Environmental Engineering)
Class, Semester	First Year M. Tech., Semester II
Course Code	5EV526
Course Name	Energy Efficient and Sustainable Buildings
Desired Requisites:	Building Materials and Construction, Building Planning and Design

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	2 Hrs./week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 2**			

Course Objectives	
1	To introduce the PG students, the scientific and engineering principles of energy
2	To impress upon the integration of new materials and traditional techniques to bring about cost effectiveness, energy efficiency and environmental friendly technologies in construction industry
3	Imparting the objective of environmental friendly building concepts during the construction and operational phases
4	To introduce the PG students, the scientific and engineering principles of energy

Course Outcomes (CO) with Bloom's Taxonomy Level		
CO1	***Grasp*** the language of energy in context to energy policies and ***interpret*** the relevance of environment and energy efficiency in context to non-renewable and renewable energy resources.	Understand
CO2	***Estimate*** the energy contribution of various materials and components in buildings and develop an ability to ***justify*** appropriate/environmental friendly/energy efficient building systems.	Analyze
CO3	***Apply*** the concept of heat exchange in buildings and adopt passive and active design strategies to maximize human comfort in buildings for tropical regions.	Apply

Module	**Module Contents**	**Hours**
I	**Energy and Environment** Global warming, causes, energy considerations, energy conservation and energy efficiency, energy systems and spatial structures, Classification of energy, primary and secondary energy, commercial and non-commercial energy, renewable and nonrenewable energy, Global primary energy reserves and consumption, energy distribution, Units of Energy with examples	4
II	**Conventional Materials and Techniques in Buildings** Constraints in Choice of building systems, Pre & post construction performance, Properties of materials, Types of Physical, Mechanical, Chemical and Thermal characteristics, Conventional materials used in construction, Embodied Energy of various building materials, Sustainability considerations.	4

III	**Concepts of Sustainable Buildings** Sustainable buildings, sustainability and objectives of Green buildings, LEED & Griha, planning aspects of sustainable buildings, energy consumption and efficiency in buildings, Design strategies, Material strategies, Parametric assessment, Env. Issues related to buildings materials.	4
IV	**Sustainable Materials and Techniques for Masonry** Felt requirements and real objectives of Green towns, Energy scenario in pre and post independent India, Need and approach to sustainability, Green building materials, Design constraints. Appropriate materials and techniques in construction: Relevance of building blocks, mortars. Stabilized mud blocks, FAL-G blocks, Hollow concrete blocks, Calcium silicate bricks, Hourdi blocks, Relevance of Lime, Lime pozollona and combination mortars for masonry, Energy consumption and comparison in building blocks, energy estimates in masonry components.	5
V	**Roofing Concepts in Green Buildings** Structural inefficiencies in Conventional roofing systems, Concepts in roofing alternatives, Rain water harvesting, Energy consumption in different roofing systems, Overall embodied energy comparisons in buildings.	5
VI	**Energy Systems in Building Maintenance** Operational Energy consumption in Buildings, Climate and human comfort, Heat exchange in buildings, Comfort criteria, Concepts of Active and Passive Energy systems in Buildings, Use of modern gadgets leading to energy efficiency.	6

Text Books	
1	Renewable Energy: Power for Sustainable Future, Ed. By Godfrey Boyle, Oxford Univ. Press, Third Edition.
2	Manual of tropical Housing and Building- Climatic Design by Koenigsberger, Ingersoll, Mayhew, Szokolay.
3	Alternative Building materials and Technologies by K.S. Jagadish, B.V.Venkatarama Reddy, K. S. Nanjunda Rao

References	
1	Passive and Low Energy Building Design for Tropical Island Climates- by N. V. Baker, Published by Commonwealth Science Council, May 1987.
2	Energy Policy in the Greenhouse, Florentin Krause, Earthscan Pub. Ltd. London.
3	World Energy Investment Outlook- Special Report, International Energy Agency, London, 2014.

Useful Links	
1	https://www.youtube.com/channel/UC35NsIdqUF3RPCM_J7djCYg

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			2			
CO2				3	2	
CO3				3	2	

Assessment
The assessment is based on 2 Tests (T1 & T2) of 20 marks each, and 1 end-semester examination (ESE) of 60 marks. Test 1 is typically based on the modules 1 & 2. Test 2 is based on modules 3 & 4 and ESE is based on all modules with 40-50% weightage on modules 1 to 4 and 50-60% weightage on modules 5 & 6.

Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember	5	5	10	**20**
Understand	10	5	15	**30**
Apply	5	5	15	**25**
Analyze		5	20	**25**
Evaluate				
Create				
Total	**20**	**20**	**60**	**100**

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Course Information

Programme	M. Tech. Civil (Environmental Engineering)
Class, Semester	First Year M. Tech., Semester II
Course Code	5EV525
Course Name	Environmental Management Systems
Desired Requisites:	Environmental Engineering Course at Graduate Level

Teaching Scheme		**Examination Scheme (Marks)**			
Lecture	2 Hrs./week	**T1**	**T2**	**ESE**	**Total**
Tutorial	-	20	20	60	100
Practical	-				
Interaction	-	**Credits: 2**			

Course Objectives

1	To provide knowledge of ecological aspects.
2	To provide knowledge of Environmental Ethics and Environmental Legislation.
3	To provide necessary knowledge of managerial tools required for assessing, analyzing and solving problems in the field of environmental management.

Course Outcomes (CO) with Bloom's Taxonomy Level

CO1	***Explain*** ecological imbalance due to various types of pollution and perceive environmental ethics and legislation.	Understand
CO2	***Choose*** appropriate methodology for EIA and auditing and assess the impacts.	Apply
CO3	***Justify*** EMS and Environmental Management Plan for infrastructural facilities.	Evaluate

Module	**Module Contents**	**Hours**
I	**Ecological Aspects and Noise Pollution** Ecological aspects: Salient features of major Eco Systems, Energy Transfer, Population Dynamics, Ecological imbalance, Preservation of Biodiversity. Land Pollution, Water Pollution due to sewage, industrial effluents and leachate, Pollution due to Nuclear Power Plants, Radioactive Waste, Thermal pollution, causes and control. Noise Pollution: Decibel Levels, Monitoring, Hazards, Control measures.	4
II	**Environmental Ethics and Legislation** Environmental Ethics: Ethics in society, Environmental consequences, Responsibility for environmental degradation, Ethical theories and codes of Ethics, Changing attitudes, Sustainable development. Environmental Legislation: Water (prevention and control of pollution) act 1974, The environmental act 1986, The Noise Pollution (Regulation and Control) Rules, 2000. Environmental economics.	5

III	**Environmental Impact Assessment (EIA)** Definitions and Concept, Scope, Objectives, Types of impacts, Elements of EIA, Baseline studies. Methodologies of EIA, Prediction of impacts and its methodology, Uncertainties in EIA, Status of EIAs in India.	5
IV	**Environmental Auditing** Definitions and concepts, Scope and Objectives, Types of audit, Accounts audit, Environmental audit statement, Qualities of environment auditor. Environmental Impact Statement (EIS).	5
V	**ISO Standards** ISO and ISO 14000 Series: Introduction, Areas covered in the series of standards, Necessity of ISO certification. Environmental management system: Evolution, Need, Elements, Benefits, ISO 14001 requirements, Steps in ISO 14001 certification, ISO 14001 and sustainable development, Integration with other systems (ISO 9000, TQM, Six Sigma), Benefits of integration.	5
VI	**Environmental Management Plan** Definition, Importance, Development, Structuring, Monitoring, Cost aspects. Strategy for siting of Industries, Environmental Labeling, Life-Cycle Assessment.	4

Text Books	
1	Canter, L. W., Environmental Impact Assessment, McGraw-Hill, 2nd Edition, 1997.
2	Agarwal, N. P., Environmental Reporting and Auditing, Raj Pub., 1st Edition, 2002.
3	Judith, P. and Eduljee, G., Environmental Impact Assessment for Waste Treatment and Disposal Facilities, John Wiley & Sons, 1st Edition, 1994.

References	
1	"Environmental Auditing", Published by CPCB, Govt. of India Publication, New Delhi.
2	Mhaskar, A.K., Environmental Audit", Media Enviro Publications, 2002.
3	K. Whitelaw and Butterworth, ISO 14001: Environmental System Handbook, 1997.

Useful Links	
1	https://www.youtube.com/watch?v=wEqrMCdNjX4
2	https://www.youtube.com/watch?v=hfLGI73N_iA
3	https://www.youtube.com/watch?v=MpR6YiSiHrs

CO-PO Mapping						
	Programme Outcomes (PO)					
	1	2	3	4	5	6
CO1			3			
CO2					3	
CO3			3			

Assessment
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Assessment Plan based on Bloom's Taxonomy Level				
Bloom's Taxonomy Level	**T1**	**T2**	**ESE**	**Total**
Remember				
Understand	10	5	20	**35**
Apply	10	5	20	**35**
Analyze				
Evaluate		10	20	**30**
Create				
Total	**20**	**20**	**60**	**100**