VIT®

Vellore Institute of Technology

(Deemed to be University under section 3 of UGC Act, 1956)

## SCHOOL OF CIVIL ENGINEERING

# M. Tech. Energy and Environmental Engineering

(M. Tech. MEE)

Curriculum

(*2018-2019 admitted students*)

## VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research.

## MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

**World class Education** : Excellence in education, grounded in ethics and critical thinking, for improvement of life.

**Cutting edge Research** : An innovation ecosystem to extend knowledge and solve critical problems.

**Impactful People** : Happy, accountable, caring and effective workforce and students.

**Rewarding Co-creations**: Active collaboration with national & international industries & universities for productivity and economic development.

**Service to Society** : Service to the region and world through knowledge and compassion.

## VISION STATEMENT OF THE SCHOOL OF CIVIL ENGINEERING

- To be internationally recognized in Civil Engineering through groundbreaking contributions and exceptional leadership for sustainable development of the society.

## MISSION STATEMENT OF THE SCHOOL OF CIVIL ENGINEERING

- To Pioneer the emerging technology in Civil Engineering.
- To address the complex societal scale challenges in areas of resilient infrastructure, smart and sustainable cities, water and energy security, climate change, mobility of goods and people, and environmental protection.
- To inspire and nurture innovative leaders and entrepreneurs.

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# M. Tech. Energy and Environmental Engineering

## PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be engineering practitioners and leaders, who would help solve industry's technological problems.

2. Graduates will be engineering professionals, innovators or entrepreneurs engaged in technology development, technology deployment, or engineering system implementation in industry.

3. Graduates will function in their profession with social awareness and responsibility.

4. Graduates will interact with their peers in other disciplines in industry and society and contribute to the economic growth of the country.

5. Graduates will be successful in pursuing higher studies in engineering or management.

6. Graduates will pursue career paths in teaching or research.

# M. Tech. Energy and Environmental Engineering

## PROGRAMME OUTCOMES (POs)

PO_01: Having an ability to apply mathematics and science in engineering Applications

PO_02: Having an ability to design a component or a product applying all the relevant standards and with realistic constraints, including public health, safety, culture, society and environment

PO_03: Having an ability to design and conduct experiments, as well as to analyse and interpret data, and synthesis of information

PO_04: Having an ability to use techniques, skills, resources and modern engineering and IT tools necessary for engineering practice

PO_05: Having problem solving ability- to assess social issues (societal, health, safety, legal and cultural) and engineering problems

PO_06: Having adaptive thinking and adaptability in relation to environmental context and sustainable development

PO_07: Having a clear understanding of professional and ethical responsibility

PO_08: Having a good cognitive load management skills related to project management and finance

# M. Tech. Energy and Environmental Engineering

## PROGRAMME SPECIFIC OUTCOMES (PSOs)

On completion of M. Tech. (Energy and Environmental Engineering) programme, graduates will be able to

PSO_01: Acquire in depth knowledge to design, analyse and evaluate the environmental systems from the global and Indian perspective to provide sustainable solutions to the Environmental Engineering Problems

PSO_02: Develop model, analyze and system simulation for performance evaluation and optimization of energy systems.

PSO_03: Independently carry out research / investigation to solve practical problems and write / present a substantial technical report / document

# M. Tech. Energy and Environmental Engineering

## CREDIT STRUCTURE

### Category-wise Credit distribution

| Category | Credits |
|---|---|
| University core (UC) | 27 |
| Programme core (PC) | 19 |
| Programme elective (PE) | 18 |
| University elective (UE) | 6 |
| Bridge course (BC) | |
| Total credits | 70 |

# M. Tech. Energy and Environmental Engineering

# DETAILED CURRICULUM

## University Core

| S. No. | Course Code | Course Title | L | T | P | J | C |
|---|---|---|---|---|---|---|---|
| 1. | MAT6001 | Advanced Statistical methods | 2 | 0 | 2 | 0 | 3 |
| 2. | ENG5001 | Fundamentals of Communication Skills | 0 | 0 | 2 | 0 | 1 |
| 3. | ENG5002 | Professional and Communication Skills | 0 | 0 | 2 | 0 | 1 |
| 4. | FRE5001 | Francais fonctionnel | 2 | 0 | 0 | 0 | 2 |
| 5. | GER5001 | Deutsch fuer Anfaenger | 2 | 0 | 0 | 0 | 2 |
| 6. | STS5001 | Essentials of Business Etiquettes | 3 | 0 | 0 | 0 | 1 |
| 7. | STS 5002 | Preparing for Industry | 3 | 0 | 0 | 0 | 1 |
| 8. | SET5001 | Science, Engineering and Technology Project – I | 0 | 0 | 0 | 0 | 2 |
| 9. | SET 5002 | Science, Engineering and Technology Project – II | 0 | 0 | 0 | 0 | 2 |
| 10. | CLE6099 | Master's Thesis | - | - | - | - | 16 |

# M. Tech. Energy and Environmental Engineering

## Programme Core

| S. No. | Course Code | Course Title | L | T | P | J | C |
|---|---|---|---|---|---|---|---|
| 1. | CLE5004 | Physicochemical, Biological Principles and Processes | 2 | 0 | 0 | 4 | 3 |
| 2. | CLE5005 | Design of Water and Wastewater Treatment Systems | 2 | 0 | 2 | 4 | 4 |
| 3. | CLE5007 | Environmental Quality Monitoring | 3 | 0 | 2 | 0 | 4 |
| 4. | MEE5018 | Renewable Energy Technologies | 2 | 0 | 2 | 4 | 4 |
| 5. | MEE5019 | Energy Audit, Conservation and Management | 3 | 0 | 0 | 4 | 4 |

# M. Tech. Energy and Environmental Engineering

## Programme Elective

| Sl. No. | Course Code | Course Title | L | T | P | J | C |
|---|---|---|---|---|---|---|---|
| 1. | CLE6005 | Solid and Hazardous Waste Management | 3 | 0 | 0 | 0 | 3 |
| 2. | CLE6006 | Environmental Geotechnology | 3 | 0 | 0 | 0 | 3 |
| 3. | CLE6007 | Energy, Environment and Climate Change | 3 | 0 | 0 | 0 | 3 |
| 4. | CLE6008 | Environmental Impact Assessment | 3 | 0 | 0 | 0 | 3 |
| 5. | CLE6009 | Air and Noise Pollution Control | 3 | 0 | 0 | 0 | 3 |
| 6. | CLE6010 | Advanced Wastewater Treatment | 3 | 0 | 0 | 0 | 3 |
| 7. | CLE6011 | Mathematical Modeling in Environmental Engineering | 3 | 0 | 0 | 0 | 3 |
| 8. | CLE6012 | Remote Sensing and GIS Applications | 2 | 0 | 2 | 0 | 3 |
| 9. | CLE6013 | Occupational Health and Industrial Safety | 3 | 0 | 0 | 0 | 3 |
| 10. | MEE5006 | Solar Energy Technologies | 3 | 0 | 0 | 0 | 3 |
| 11. | MEE5020 | Alternative Fuels | 3 | 0 | 0 | 0 | 3 |
| 12. | MEE6050 | Power Plant Engineering | 3 | 0 | 0 | 0 | 3 |
| 13. | MEE6051 | Wind Energy Technology | 3 | 0 | 0 | 0 | 3 |
| 14. | MEE6053 | Energy Systems Modeling and Analysis | 3 | 0 | 0 | 0 | 3 |
| 15. | MEE6054 | Energy in Built Environment | 3 | 0 | 0 | 0 | 3 |

| MAT6001 | ADVANCED STATISTICAL METHODS | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 2 | 0 | 2 | 0 | 3 |
| Pre-requisite | None | Syllabus Version | | | | |
| | | 2.0 | | | | |

**Course Objectives**

1. To provide students with a framework that will help them choose the appropriate descriptive statistics in various data analysis situations.
2. To analyse distributions and relationships of real-time data.
3. To apply estimation and testing methods to make inference and modelling techniques for decision making using various techniques including multivariate analysis.

**Expected Course Outcome**

At the end of the course the students are expected to

1. Understand the concept of correlation and regression model and able to interpret the effect of variables, regression coefficients, coefficient of determination.
2. Make appropriate decisions using inferential statistical tools that are central to experimental research.
3. Understand the statistical forecasting methods and model fitting by graphical interpretation of time series data.
4. Construct standard experimental designs and describe what statistical models can be estimated using the data.
5. Demonstrate R programming for statistical data

| Module: 1 | Basic Statistical Tools for Analysis | 4 hours |
|---|---|---|

Summary Statistics, Correlation and Regression, Concept of $R^2$ and Adjusted $R^2$ and Partial and Multiple Correlation, Fitting of simple and Multiple Linear regression, Explanation and Assumptions of Regression Diagnostics

| Module: 2 | Statistical inference | 9 hours |
|---|---|---|

Basic Concepts, Normal distribution-Area properties, Steps in tests of significance –large sample tests-Z tests for Means and Proportions, Small sample tests –t-test for Means, F test for Equality of Variances, Chi-square test for independence of Attributes.

| Module: 3 | Modelling and Forecasting Methods | 9 hours |
|---|---|---|

Introduction: Concept of Linear and Non Liner Forecasting model ,Concepts of Trend, Exponential Smoothing, Linear and Compound Growth model, Fitting of Logistic curve and their Applications, Moving Averages, Forecasting accuracy tests.
**Probability models for time series:** Concepts of AR, ARMA and ARIMA models.

| Module: 4 | Design of Experiments | 6 hours |
|---|---|---|

Analysis of variance – one and two way classifications – Principle of design of experiments, CRD – RBD – LSD, Concepts of $2^2$ and $2^3$ factorial experiments.

| Module: 5 | Contemporary Issues | 2 hours |
|---|---|---|

Industry Expert Lecture

| Total Lecture hours | 30 hours |
|---|---|

**Text Book(s)**

1. Applied Statistics and Probability for Engineers, Douglas C. Montgomery George C. Runger, 6th edition, John Wiley & Sons (2016).
2. Time Series Analysis and Its Applications with R Examples, Shumway, Robert H., Stoffer, David S., 4th edition, Springer publications (2017).

**Reference Books**

1. The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Trevor Hastie and Robert Tibshirani, 2nd Edition, Springer Series, (2017).
2. Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences, J. Susan Milton and Jesse Arnold, McGraw Hill education (2017).

**Mode of Evaluation :** Digital Assignments, Quiz, Continuous Assessments, Final Assessment Test

**List of Challenging Experiments (Indicative)**

| | | |
|---|---|---|
| 1. | Computing Summary Statistics using real time data. | 3 hours |
| 2. | Plotting and visualizing data using Tabulation and Graphical Representations. | 3 hours |
| 3. | Applying simple linear and multiple linear regression models to real dataset; computing and interpreting the coefficient of determination for scale data. | 3 hours |
| 4. | Testing of hypothesis for Large sample tests for real-time problems. | 2 hours |
| 5. | Testing of hypothesis for Small sample tests for One and Two Sample mean and paired comparison (Pre-test and Post-test). | 2 hours |
| 6. | Testing of hypothesis for Small Sample tests for F-test. | 2 hours |
| 7. | Testing of hypothesis for Small Sample tests for Chi-square test. | 2 hours |
| 8. | Applying Time series analysis-Trends. Growth, Logistic, Exponential models. | 2 hours |
| 9. | Applying Time series model AR, ARMA and ARIMA and testing Forecasting accuracy tests. | 3 hours |
| 10. | Performing ANOVA (one-way and two-way), CRD, RBD and LSD for real dataset. | 3 hours |
| 11. | Performing $2^2$ factorial experiments with real time Applications. | 2 hours |
| 12. | Performing $2^3$ factorial experiments with real time Applications. | 3 hours |
| **Total Laboratory Hours** | | **30 hours** |

**Mode of Evaluation:** Weekly Assessments, Final Assessment Test

| | | | |
|---|---|---|---|
| **Recommended by Board of Studies** | 25.02.2017 | | |
| **Approved by Academic Council** | No. 46 | **Date** | 24.08.2017 |

| ENG5001 | FUNDAMENTALS OF COMMUNICATION SKILLS | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 0 | 1 |
| **Pre-requisite** | Not cleared EPT (English Proficiency Test) | **Syllabus version** | | | | |
| | | 1.0 | | | | |

**Course Objectives:**

1. To enable learners learn basic communication skills - Listening, Speaking, Reading and Writing
2. To help learners apply effective communication in social and academic context
3. To make students comprehend complex English language through listening and reading

**Expected Course Outcome:**

1. Enhance the listening and comprehension skills of the learners
2. Acquire speaking skills to express their thoughts freely and fluently
3. Learn strategies for effective reading
4. Write grammatically correct sentences in general and academic writing
5. Develop technical writing skills like writing instructions, transcoding etc.,

| **Module: 1** | **Listening** | **8 hours** |
|---|---|---|

Understanding Conversation
Listening to Speeches
Listening for Specific Information

| **Module: 2** | **Speaking** | **4 hours** |
|---|---|---|

Exchanging Information
Describing Activities, Events and Quantity

| **Module: 3** | **Reading** | **6 hours** |
|---|---|---|

Identifying Information
Inferring Meaning
Interpreting text

| **Module: 4** | **Writing: Sentence** | **8 hours** |
|---|---|---|

Basic Sentence Structure
Connectives
Transformation of Sentences
Synthesis of Sentences

| **Module: 5** | **Writing: Discourse** | **4 hours** |
|---|---|---|

Instructions
Paragraph
Transcoding

| **Total Lecture hours** | **30 hours** |
|---|---|

**Text Book(s)**

1. Redston, Chris, Theresa Clementson, and Gillie Cunningham. *Face2face Upper Intermediate Student's Book.* 2013, Cambridge University Press.

**Reference Books**

1. Chris Juzwiak *Stepping Stones: A guided approach to writing sentences and Paragraphs (Second Edition)*, 2012, Library of Congress.
2. Clifford A Whitcomb & Leslie E Whitcomb, *Effective Interpersonal and Team Communication Skills for Engineers*, 2013, John Wiley & Sons, Inc., Hoboken: New Jersey.
3. ArunPatil, Henk Eijkman & Ena Bhattacharya, *New Media Communication Skills for Engineers and IT Professionals,* 2012, IGI Global, Hershey PA.
4. Judi Brownell, *Listening: Attitudes, Principles and Skills*, 2016, 5th Edition, Routledge: USA
5. John Langan, Ten Steps to Improving College Reading Skills, 2014, 6th Edition, Townsend Press: USA
6. Redston, Chris, Theresa Clementson, and Gillie Cunningham. *Face2face Upper Intermediate Teacher's Book*. 2013, Cambridge University Press.

**Mode of Evaluation:** CAT / Assignment / Quiz / FAT / Project / Seminar

**List of Challenging Experiments (Indicative)**

| | | |
|---|---|---|
| 1. | Familiarizing students to adjectives through brainstorming adjectives with all letters of the English alphabet and asking them to add an adjective that starts with the first letter of their name as a prefix. | 2 hours |
| 2. | Making students identify their peer who lack Pace, Clarity and Volume during presentation and respond using Symbols. | 4 hours |
| 3. | Using Picture as a tool to enhance learners speaking and writing skills | 2 hours |
| 4. | Using Music and Songs as tools to enhance pronunciation in the target language / Activities through VIT Community Radio | 2 hours |
| 5. | Making students upload their Self- introduction videos in Vimeo.com | 4 hours |
| 6. | Brainstorming idiomatic expressions and making them use those in to their writings and day to day conversation | 4 hours |
| 7. | Making students Narrate events by adding more descriptive adjectives and add flavor to their language / Activities through VIT Community Radio | 4 hours |
| 8 | Identifying the root cause of stage fear in learners and providing remedies to make their presentation better | 4 hours |
| 9 | Identifying common Spelling & Sentence errors in Letter Writing and other day to day conversations | 4 hours |
| 10. | Discussing FAQ's in interviews with answers so that the learner gets a better insight in to interviews / Activities through VIT Community Radio | 2 hours |
| **Total Laboratory Hours** | | **30 hours** |

**Mode of evaluation:** Online Quizzes, Presentation, Role play, Group Discussions, Assignments, Mini Project

| | | | |
|---|---|---|---|
| **Recommended by Board of Studies** | 22.07.2017 | | |
| **Approved by Academic Council** | No. 46 | **Date** | 24.08.2017 |

| ENG5002 | PROFESSIONAL AND COMMUNICATION SKILLS | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 0 | 0 | 2 | 0 | 1 |
| Pre-requisite | ENG5001 | Syllabus version | | | | |
| | | 1.1 | | | | |

**Course Objectives:**

1. To enable students to develop effective Language and Communication Skills
2. To enhance students' Personal and Professional skills
3. To equip the students to create an active digital footprint

**Expected Course Outcome:**

1. Improve inter-personal communication skills
2. Develop problem solving and negotiation skills
3. Learn the styles and mechanics of writing research reports
4. Cultivate better public speaking and presentation skills
5. Apply the acquired skills and excel in a professional environment

| | | |
|---|---|---|
| **Module: 1** | **Personal Interaction** | **2 hours** |
| Introducing Oneself- one's career goals<br>Activity: SWOT Analysis | | |
| **Module: 2** | **Interpersonal Interaction** | **2 hours** |
| Interpersonal Communication with the team leader and colleagues at the workplace<br>Activity: Role Plays/Mime/Skit | | |
| **Module: 3** | **Social Interaction** | **2 hours** |
| Use of Social Media, Social Networking, gender challenges<br>Activity: Creating LinkedIn profile, blogs | | |
| **Module: 4** | **Résumé Writing** | **4 hours** |
| Identifying job requirement and key skills<br>Activity: Prepare an Electronic Résumé | | |
| **Module: 5** | **Interview Skills** | **4 hours** |
| Placement / Job Interview, Group Discussions<br>Activity: Mock Interview and mock group discussion | | |
| **Module: 6** | **Report Writing** | **4 hours** |
| Language and Mechanics of Writing<br>Activity: Writing a Report | | |
| **Module: 7** | **Study Skills: Note making** | **2 hours** |
| Summarizing the report<br>Activity: Abstract, Executive Summary, Synopsis | | |
| **Module: 8** | **Interpreting skills** | **2 hours** |
| Interpret data in tables and graphs<br>Activity: Transcoding | | |
| **Module: 9** | **Presentation Skills** | **4 hours** |
| Oral Presentation using Digital Tools<br>Activity: Oral presentation on the given topic using appropriate non-verbal cues | | |

| **Module: 10** | **Problem Solving Skills** | **4 hours** |
|---|---|---|
| Problem Solving & Conflict Resolution<br>Activity: Case Analysis of a Challenging Scenario | | |
| **Total Lecture hours** | | **30 hours** |

**Text Book(s)**

1. Bhatnagar Nitin and Mamta Bhatnagar, *Communicative English For Engineers And Professionals*, 2010, Dorling Kindersley (India) Pvt. Ltd.

**Reference Books**

1. Jon Kirkman and Christopher Turk, *Effective Writing: Improving Scientific, Technical and Business Communication,* 2015, Routledge
2. Diana Bairaktarova and Michele Eodice, *Creative Ways of Knowing in Engineering*, 2017, Springer International Publishing
3. Clifford A Whitcomb & Leslie E Whitcomb, *Effective Interpersonal and Team Communication Skills for Engineers*, 2013, John Wiley & Sons, Inc., Hoboken: New Jersey.
4. Arun Patil, Henk Eijkman & Ena Bhattacharya, *New Media Communication Skills for Engineers and IT Professionals,* 2012, IGI Global, Hershey PA.

**Mode of Evaluation:** CAT / Assignment / Quiz / FAT / Project / Seminar

**List of Challenging Experiments (Indicative)**

| | | |
|---|---|---|
| 1. | SWOT Analysis – Focus specially on describing two strengths and two weaknesses | 2 hours |
| 2. | Role Plays / Mime / Skit -- Workplace Situations | 4 hours |
| 3. | Use of Social Media – Create a LinkedIn Profile and also write a page or two on areas of interest | 2 hours |
| 4. | Prepare an Electronic Résumé and upload the same in vimeo | 2 hours |
| 5. | Group discussion on latest topics | 4 hours |
| 6. | Report Writing – Real-time reports | 2 hours |
| 7. | Writing an Abstract, Executive Summary on short scientific or research articles | 4 hours |
| 8. | Transcoding – Interpret the given graph, chart or diagram | 2 hours |
| 9. | Oral presentation on the given topic using appropriate non-verbal cues | 4 hours |
| 10. | Problem Solving -- Case Analysis of a Challenging Scenario | 4 hours |
| **Total Laboratory Hours** | | **32 hours** |

**Mode of evaluation:** Online Quizzes, Presentation, Role play, Group Discussions, Assignments, Mini Project

| | | | |
|---|---|---|---|
| **Recommended by Board of Studies** | 22.07.2017 | | |
| **Approved by Academic Council** | No. 47 | **Date** | 05.10.2017 |

| FRE5001 | FRANCAIS FONCTIONNEL | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 2 | 0 | 0 | 0 | 2 |
| **Pre-requisite** | **Nil** | **Syllabus version** | | | | |
| | | 1.0 | | | | |

**Course Objectives:**

The course gives students the necessary background to:

1. Demonstrate competence in reading, writing, and speaking basic French, including knowledge of vocabulary (related to profession, emotions, food, workplace, sports/hobbies, classroom and family).
2. Achieve proficiency in French culture oriented view point.

**Expected Course Outcome:**

The students will be able to

1. Remember the daily life communicative situations via personal pronouns, emphatic pronouns, salutations, negations, interrogations etc.
2. Create communicative skill effectively in French language via regular / irregular verbs.
3. Demonstrate comprehension of the spoken / written language in translating simple sentences.
4. Understand and demonstrate the comprehension of some particular new range of unseen written materials.
5. Demonstrate a clear understanding of the French culture through the language studied.

| **Module: 1** | **Saluer, Se présenter, Etablir des contacts** | **3 hours** |
|---|---|---|

Les Salutations, Les nombres (1-100), Les jours de la semaine, Les mois de l'année, Les Pronoms Sujets, Les Pronoms Toniques, La conjugaison des verbes réguliers, La conjugaison des verbes irréguliers- avoir / être / aller / venir / faire etc.

| **Module: 2** | **Présenter quelqu'un, Chercher un(e) correspondant(e), Demander des nouvelles d'une personne.** | **3 hours** |
|---|---|---|

La conjugaison des verbes Pronominaux, La Négation, L'interrogation avec *'Est-ce que ou sans Est-ce que'*.

| **Module: 3** | **Situer un objet ou un lieu, Poser des questions** | **4 hours** |
|---|---|---|

L'article (défini/ indéfini), Les prépositions (à/en/au/aux/sur/dans/avec etc.), L'article contracté, Les heures en français, La Nationalité du Pays, L'adjectif (La Couleur, l'adjectif possessif, l'adjectif démonstratif/ l'adjectif interrogatif (quel/quelles/quelle/quelles), L'accord des adjectifs avec le nom, L'interrogation avec Comment / Combien / Où etc.,

| **Module: 4** | **Faire des achats, Comprendre un texte court, Demander et indiquer le chemin.** | **6 hours** |
|---|---|---|

La traduction simple : (français-anglais / anglais –français)

| **Module: 5** | **Trouver les questions, Répondre aux questions générales en français.** | **5 hours** |
|---|---|---|

L'article Partitif, Mettez les phrases aux pluriels, Faites une phrase avec les mots donnés, Exprimez les phrases données au Masculin ou Féminin, Associez les phrases.

| **Module: 6** | **Comment ecrire un passage** | **3 hours** |
|---|---|---|

**Décrivez :**
La Famille / La Maison, / L'université / Les Loisirs / La Vie quotidienne etc.

| | | |
|---|---|---|
| **Module: 7** | **Comment ecrire un dialogue** | **4 hours** |
| **Dialogue:**<br>a) Réserver un billet de train<br>b) Entre deux amis qui se rencontrent au café<br>c) Parmi les membres de la famille<br>d) Entre le client et le médecin | | |
| **Module: 8** | **Invited Talk: Native speakers** | **2 hours** |
| **Total Lecture hours** | | **30 hours** |

**Text Book(s)**

1. Echo-1, Méthode de français, J. Girardet, J. Pécheur, Publisher CLE International, Paris 2010.
2. Echo-1, Cahier d'exercices, J. Girardet, J. Pécheur, Publisher CLE International, Paris 2010.

**Reference Books**

1. CONNEXIONS 1, Méthode de français, Régine Mérieux, Yves Loiseau, Les Éditions Didier, 2004.
2. CONNEXIONS 1, Le cahier d'exercices, Régine Mérieux, Yves Loiseau, Les Éditions Didier, 2004.
3. ALTER EGO 1, Méthode de français, Annie Berthet, Catherine Hugo, Véronique M. Kizirian, Béatrix Sampsonis, Monique Waendendries, Hachette livre 2006.

**Mode of Evaluation:** CAT / Assignment / Quiz / FAT

| | | | |
|---|---|---|---|
| **Recommended by Board of Studies** | | | |
| **Approved by Academic Council** | No. 41 | **Date** | 17.06.2016 |

| GER5001 | DEUTSCH FÜR ANFÄNGER | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 2 | 0 | 0 | 0 | 2 |
| **Pre-requisite** | **NIL** | **Syllabus version** | | | | |
| | | 1.0 | | | | |

**Course Objectives:**

The course gives students the necessary background to:

1. Enable students to read and communicate in German in their day to day life
2. Become industry-ready
3. Make them understand the usage of grammar in the German Language.

**Expected Course Outcome:**

The students will be able to

1. Create the basics of German language in their day to day life.
2. Understand the conjugation of different forms of regular/irregular verbs.
3. Understand the rule to identify the gender of the Nouns and apply articles appropriately.
4. Apply the German language skill in writing corresponding letters, E-Mails etc.
5. Create the talent of translating passages from English-German and vice versa and to frame simple dialogues based on given situations.

| **Module: 1** | | **3 hours** |
|---|---|---|

Einleitung, Begrüssungsformen, Landeskunde, Alphabet, Personalpronomen, Verb Konjugation, Zahlen (1-100), W-fragen, Aussagesätze, Nomen – Singular und Plural

**Lernziel:**

Elementares Verständnis von Deutsch, Genus- Artikelwörter

| **Module: 2** | | **3 hours** |
|---|---|---|

Konjugation der Verben (regelmässig /unregelmässig) die Monate, die Wochentage, Hobbys, Berufe, Jahreszeiten, Artikel, Zahlen (Hundert bis eine Million), Ja-/Nein- Frage, Imperativ mit Sie

**Lernziel** :

Sätze schreiben, über Hobbys erzählen, über Berufe sprechen usw.

| **Module: 3** | | **4 hours** |
|---|---|---|

Possessivpronomen, Negation, Kasus- AkkusatitvundDativ (bestimmter, unbestimmterArtikel), trennnbare verben, Modalverben, Adjektive, Uhrzeit, Präpositionen, Mahlzeiten, Lebensmittel, Getränke

**Lernziel :**

Sätze mit Modalverben, Verwendung von Artikel, über Länder und Sprachen sprechen, über eine Wohnung beschreiben.

| **Module:4** | | **6 hours** |
|---|---|---|

Übersetzungen : (Deutsch – Englisch / Englisch – Deutsch)

**Lernziel :**

Grammatik – Wortschatz – Übung

| | | |
|---|---|---|
| **Module: 5** | | **5 hours** |
| Leseverständnis, Mindmap machen, Korrespondenz- Briefe, Postkarten, E-Mail<br>**Lernziel :**<br>Wortschatzbildung und aktiver Sprach gebrauch | | |
| **Module: 6** | | **3 hours** |
| **Aufsätze :**<br>Meine Universität, Das Essen, mein Freund oder meine Freundin, meine Familie, ein Fest in Deutschland usw | | |
| **Module: 7** | | **4 hours** |
| **Dialoge:**<br>1. Gespräche mit Familienmitgliedern, Am Bahnhof,<br>2. Gespräche beim Einkaufen ; in einem Supermarkt ; in einer Buchhandlung ;<br>3. in einem Hotel - an der Rezeption ;ein Termin beim Arzt.<br>4. Treffen im Cafe | | |
| **Module: 8** | | **2 hours** |
| Guest Lectures / Native Speakers / Feinheiten der deutschen Sprache, Basis information über die deutschsprachigen Länder | | |
| **Total Lecture hours** | | **30 hours** |
| **Text Book(s)** | | |
| 1. Studio d A1 Deutsch als Fremdsprache, Hermann Funk, Christina Kuhn, Silke Demme : 2012 | | |
| **Reference Books** | | |
| 1. Netzwerk Deutsch als Fremdsprache A1, Stefanie Dengler, Paul Rusch, Helen Schmtiz, Tanja Sieber, 2013.<br>2. Lagune, Hartmut Aufderstrasse, Jutta Müller, Thomas Storz, 2012.<br>3. Deutsche SprachlehrefürA Usländer, Heinz Griesbach, Dora Schulz, 2011.<br>4. ThemenAktuell 1, Hartmurt Aufderstrasse, Heiko Bock, MechthildGerdes, Jutta Müller und Helmut Müller, 2010.<br>www.goethe.de<br>wirtschaftsdeutsch.de<br>hueber.de, klett-sprachen.de<br>www.deutschtraning.org | | |
| **Mode of Evaluation:** CAT / Assignment / Quiz / FAT | | |
| **Recommended by Board of Studies** | | |
| **Approved by Academic Council** | No. 41 | **Date** 17.06.2016 |

| STS5001 | ESSENTIALS OF BUSINESS ETIQUETTES | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 0 | 1 |
| Pre-requisite | | Syllabus version | | | | |
| | | 2.0 | | | | |

**Course Objectives:**

1. To develop the students' logical thinking skills
2. To learn the strategies of solving quantitative ability problems
3. To enrich the verbal ability of the students
4. To enhance critical thinking and innovative skills

**Expected Course Outcome:**

1. Enabling students to use relevant aptitude and appropriate language to express themselves
2. To communicate the message to the target audience clearly

| Module: 1 | **Business Etiquette: Social and Cultural Etiquette and Writing Company Blogs and Internal Communications and Planning and Writing press release and meeting notes** | **9 hours** |
|---|---|---|

Value, Manners, Customs, Language, Tradition, Building a blog, Developing brand message, FAQs', Assessing Competition, Open and objective Communication, Two way dialogue, Understanding the audience, Identifying, Gathering Information,. Analysis, Determining, Selecting plan, Progress check, Types of planning, Write a short, catchy headline, Get to the Point –summarize your subject in the first paragraph., Body – Make it relevant to your audience,

| Module: 2 | **Study skills – Time management skills** | **3 hours** |
|---|---|---|

Prioritization, Procrastination, Scheduling, Multitasking, Monitoring, Working under pressure and adhering to deadlines

| Module: 3 | **Presentation skills – Preparing presentation and Organizing materials and Maintaining and preparing visual aids and Dealing with questions** | **7 hours** |
|---|---|---|

10 Tips to prepare PowerPoint presentation, Outlining the content, Passing the Elevator Test, Blue sky thinking, Introduction , body and conclusion, Use of Font, Use of Color, Strategic presentation, Importance and types of visual aids, Animation to captivate your audience, Design of posters, Setting out the ground rules, Dealing with interruptions, Staying in control of the questions, Handling difficult questions

| Module: 4 | **Quantitative Ability -L1 – Number properties and Averages and Progressions and Percentages and Ratios** | **11 hours** |
|---|---|---|

Number of factors, Factorials, Remainder Theorem, Unit digit position, Tens digit position, Averages, Weighted Average, Arithmetic Progression, Geometric Progression, Harmonic Progression, Increase & Decrease or successive increase, Types of ratios and proportions

| Module: 5 | **Reasoning Ability-L1 – Analytical Reasoning** | **8 hours** |
|---|---|---|

Data Arrangement(Linear and circular & Cross Variable Relationship), Blood Relations, Ordering / ranking / grouping, Puzzle test, Selection Decision table

| Module: 6 | **Verbal Ability-L1 – Vocabulary Building** | **7 hours** |
|---|---|---|

Synonyms & Antonyms, One word substitutes, Word Pairs, Spellings, Idioms, Sentence completion, Analogies

| | |
|---|---|
| **Total Lecture hours** | **45 hours** |

**Reference Books**

1. Kerry Patterson, Joseph Grenny, Ron McMillan, Al Switzler (2001) Crucial Conversations: Tools for Talking When Stakes are High. Bangalore. McGraw-Hill Contemporary.
2. Dale Carnegie, (1936) How to Win Friends and Influence People. New York. Gallery Books.
3. Scott Peck. M (1978) Road Less Travelled. New York City. M. Scott Peck.
4. FACE (2016) Aptipedia Aptitude Encyclopedia. Delhi. Wiley publications.
5. ETHNUS (2013) Aptimithra. Bangalore. McGraw-Hill Education Pvt. Ltd.

**Websites:**

| | |
|---|---|
| 1. | **www.chalkstreet.com** |
| 2. | **www.skillsyouneed.com** |
| 3. | **www.mindtools.com** |
| 4. | **www.thebalance.com** |
| 5. | **www.eguru.ooo** |

**Mode of Evaluation**: FAT, Assignments, Projects, Case studies, Role plays, 3 Assessments with Term End FAT (Computer Based Test)

| | | | |
|---|---|---|---|
| **Recommended by Board of Studies** | 09.06.2017 | | |
| **Approved by Academic Council** | No. 45 | **Date** | 15.06.2017 |

| STS5002 | PREPARING FOR INDUSTRY | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 0 | 1 |
| Pre-requisite | | Syllabus version | | | | |
| | | 2.0 | | | | |

**Course Objectives:**

1. To develop the students' logical thinking skills
2. To learn the strategies of solving quantitative ability problems
3. To enrich the verbal ability of the students
4. To enhance critical thinking and innovative skills

**Expected Course Outcome:**

1. Enabling students to simplify, evaluate, analyze and use functions and expressions to simulate real situations to be industry ready.

| Module: 1 | Interview skills – Types of interview and Techniques to face remote interviews and Mock Interview | 3 hours |
|---|---|---|

Structured and unstructured interview orientation, Closed questions and hypothetical questions, Interviewers' perspective, Questions to ask/not ask during an interview, Video interview, Recorded feedback, Phone interview preparation, Tips to customize preparation for personal interview, Practice rounds

| Module: 2 | Resume skills – Resume Template and Use of power verbs and Types of resume and Customizing resume | 2 hours |
|---|---|---|

Structure of a standard resume, Content, color, font, Introduction to Power verbs and Write up, Quiz on types of resume, Frequent mistakes in customizing resume, Layout - Understanding different company's requirement, Digitizing career portfolio

| Module: 3 | Emotional Intelligence - L1 – Transactional Analysis and Brain storming and Psychometric Analysis and Rebus Puzzles/Problem Solving | 12 hours |
|---|---|---|

Introduction, Contracting, ego states, Life positions, Individual Brainstorming, Group Brainstorming, Stepladder Technique, Brain writing, Crawford's Slip writing approach, Reverse brainstorming, Star bursting, Charlette procedure, Round robin brainstorming, Skill Test, Personality Test, More than one answer, Unique ways

| Module:4 | Quantitative Ability-L3 – Permutation-Combinations and Probability and Geometry and mensuration and Trigonometry and Logarithms and Functions and Quadratic Equations and Set Theory | 14 hours |
|---|---|---|

Counting, Grouping, Linear Arrangement, Circular Arrangements, Conditional Probability, Independent and Dependent Events, Properties of Polygon, 2D & 3D Figures, Area & Volumes, Heights and distances, Simple trigonometric functions, Introduction to logarithms, Basic rules of logarithms, Introduction to functions, Basic rules of functions, Understanding Quadratic Equations, Rules & probabilities of Quadratic Equations, Basic concepts of Venn Diagram

| | | |
|---|---|---|
| **Module: 5** | **Reasoning ability-L3 – Logical reasoning and Data Analysis and Interpretation** | **7 hours** |
| Syllogisms, Binary logic, Sequential output tracing, Crypto arithmetic, Data Sufficiency, Data interpretation-Advanced, Interpretation tables, pie charts & bar chats | | |
| **Module: 6** | **Verbal Ability-L3 – Comprehension and Logic** | **7 hours** |
| Reading comprehension, Para Jumbles, Critical Reasoning (a) Premise and Conclusion, (b) Assumption & Inference, (c) Strengthening & Weakening an Argument | | |
| | **Total Lecture hours** | **45 hours** |

**Reference Books**

1. Michael Farra and JIST Editors (2011) Quick Resume & Cover Letter Book: Write and Use an Effective Resume in Just One Day. Saint Paul, Minnesota. Jist Works.
2. Daniel Flage Ph. D (2003) The Art of Questioning: An Introduction to Critical Thinking. London. Pearson.
3. David Allen (2002) Getting Things done: The Art of Stress - Free productivity. New York City. Penguin Books.
4. FACE (2016) Aptipedia Aptitude Encyclopedia. Delhi. Wiley publications.
5. ETHNUS (2013) Aptimithra. Bangalore. McGraw-Hill Education Pvt. Ltd.

**Websites:**

| | |
|---|---|
| 1. | **www.chalkstreet.com** |
| 2. | **www.skillsyouneed.com** |
| 3. | **www.mindtools.com** |
| 4. | **www.thebalance.com** |
| 5. | **www.eguru.ooo** |

**Mode of Evaluation**: FAT, Assignments, Projects, Case studies, Role plays, 3 Assessments with Term End FAT (Computer Based Test)

| | | | |
|---|---|---|---|
| **Recommended by Board of Studies** | 09.06.2017 | | |
| **Approved by Academic Council** | No. 45 | **Date** | 15.06.2017 |

| SET5001 | SCIENCE, ENGINEERING AND TECHNOLOGY PROJECT– I | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | | | | | 2 |
| **Pre-requisite** | | **Syllabus Version** | | | | |
| **Anti-requisite** | | 1.0 | | | | |

**Course Objectives:**

1. To provide opportunity to involve in research related to science / engineering
2. To inculcate research culture
3. To enhance the rational and innovative thinking capabilities

**Expected Course Outcome:**

On completion of this course, the student should be able to:

1. Identify problems that have relevance to societal / industrial needs
2. Exhibit independent thinking and analysis skills
3. Demonstrate the application of relevant science / engineering principles

**Modalities / Requirements**

1. Individual or group projects can be taken up
2. Involve in literature survey in the chosen field
3. Use Science/Engineering principles to solve identified issues
4. Adopt relevant and well-defined / innovative methodologies to fulfill the specified objective
5. Submission of scientific report in a specified format (after plagiarism check)

**Student Assessment :** Periodical reviews, oral / poster presentation

| | | | |
|---|---|---|---|
| **Recommended by Board of Studies** | 17.08.2017 | | |
| **Approved by Academic Council** | No. 47 | **Date** | 05.10.2017 |

| SET5002 | SCIENCE, ENGINEERING AND TECHNOLOGY PROJECT– II | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | | | | | 2 |
| **Pre-requisite** | | **Syllabus Version** | | | | |
| **Anti-requisite** | | 1.0 | | | | |

**Course Objectives:**

1. To provide opportunity to involve in research related to science / engineering
2. To inculcate research culture
3. To enhance the rational and innovative thinking capabilities

**Expected Course Outcome:**

On completion of this course, the student should be able to:

1. Identify problems that have relevance to societal / industrial needs
2. Exhibit independent thinking and analysis skills
3. Demonstrate the application of relevant science / engineering principles

**Modalities / Requirements**

1. Individual or group projects can be taken up
2. Involve in literature survey in the chosen field
3. Use Science/Engineering principles to solve identified issues
4. Adopt relevant and well-defined / innovative methodologies to fulfill the specified objective
5. Submission of scientific report in a specified format (after plagiarism check)

**Student Assessment :** Periodical reviews, oral / poster presentation

| | | | |
|---|---|---|---|
| **Recommended by Board of Studies** | 17.08.2017 | | |
| **Approved by Academic Council** | No. 47 | **Date** | 05.10.2017 |

| CLE6099 | Master's Thesis | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 0 | 0 | 0 | 0 | 16 |
| Pre-requisite | As per the academic regulations | Syllabus version | | | | |
| | | 1.0 | | | | |

**Course Objectives:**

To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field and also to give research orientation.

**Expected Course Outcome:**

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

1. Formulate specific problem statements for ill-defined real life problems with reasonable assumptions and constraints.
2. Perform literature search and / or patent search in the area of interest.
3. Conduct experiments / Design and Analysis / solution iterations and document the results.
4. Perform error analysis / benchmarking / costing
5. Synthesise the results and arrive at scientific conclusions / products / solution
6. Document the results in the form of technical report / presentation

**Contents**

1. Capstone Project may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
2. Project can be for two semesters based on the completion of required number of credits as per the academic regulations.
3. Should be individual work.
4. Carried out inside or outside the university, in any relevant industry or research institution.
5. Publications in the peer reviewed journals / International Conferences will be an added advantage.

**Mode of Evaluation:** Periodic reviews, Presentation, Final oral viva, Poster submission

| | | | |
|---|---|---|---|
| **Recommended by Board of Studies** | 10.06.2016 | | |
| **Approved by Academic Council** | No. 41 | **Date** | 17.06.2016 |

| CLE5004 | PHYSICOCHEMICAL, BIOLOGICAL PRINCIPLES AND PROCESSES | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 2 | 0 | 0 | 4 | 3 |
| Pre-requisite | Nil | Syllabus version | | | | |
| | | 1.0 | | | | |

**Course Objectives:**

1. To study about the solid- liquid- gas interactions.
2. To understand about process kinetics.
3. To deal with the microbial applications in environmental engineering.

**Expected Course Outcome:**

At the end of the course, the student will be able to
1. Understand the significance of water in the environment.
2. Relate the mass transfer and transport of impurities in the system.
3. Understand the chemical kinetics and isotherm model.
4. Infer the significance of ecosystem and biodiversity.
5. Appraise the biochemistry and enzyme kinetics.
6. Understand the microbiological principles and degradation processes.

| Module: 1 | Resource management and chemistry | 4 hours |
|---|---|---|

Water resources management, Water management plan, Water Chemistry – Fundamentals, Solid-Liquid-Gas interactions

| Module: 2 | Mass transfer and transport | 4 hours |
|---|---|---|

Concepts of Mass transfer and transport of impurities in surface and ground water, diffusion, dispersion. Physical and Chemical interactions due to various forces.

| Module: 3 | Chemical kinetics and isotherm models | 4 hours |
|---|---|---|

Fundamental concepts of chemical kinetics, Kinetics of complex systems, Kinetic reaction in gas, liquid and solid states, Non – isothermal methods in kinetics, Chemical equilibrium – Rate laws and rate constant

| Module: 4 | Fundamental of ecosystem and biodiversity | 4 hours |
|---|---|---|

Ecosystems; Fundamental processes – Ecological flow, tradeoff and biodiversity, Ecological hyper cycles, Ecosystem services in carbon dynamics/ carbon sequestration, biodiversity, land – surface energy balance

| Module: 5 | Biochemistry of wastewater treatment | 3 hours |
|---|---|---|

Biochemistry – Fundamentals, Enzymes – Enzyme kinetics, immobilization techniques, industrial application of enzymes.

| Module: 6 | Microbiology of wastewater treatment | 6 hours |
|---|---|---|

Microbiological concepts; Microbiology of waste water treatment, Pathogens behavior in waste water treatment, Microbes in nature – Bio mineralization, Microbial weathering and bioremediation.

| | | |
|---|---|---|
| **Module: 7** | **Principles of biological processes** | **3 hours** |
| Cells – Fundamentals, Cell cultivation, Cell kinetics and fermenter design Genetic engineering. Bioconcentration – Bioaccumulation, biomagnification, bioassay, biomonitoring, bioleaching | | |
| **Module: 8** | **Contemporary issues** | **2 hours** |
| **Total Lecture hours** | | **30 hours** |
| **J components** | | **60 hrs** |
| Challenging projects will be given to the students | | |

**Text Book(s)**

1. Jeremy M. Berg, John L. Tymoczko, LubertStryer, Gregory J. Gatto, Jr., (2012) – "Biochemistry", 7th edition, W. H. Freeman.
2. Eunika Mercier - Laurent, (2011) "Innovation Ecosystems Book", Wiley-ISTE.
3. James E. House, (2007), "Principles of Chemical Kinetics Book" 2nd edition, Academic Press.

**Reference Books**

1. Larry L. Barton, Diana E. Northup, (2011), "Microbial Ecology Book", Wiley-Blackwell.
2. Brian Moss, (2010), "Ecology of Fresh Waters - A View for the Twenty-First Century Book", 4th edition, Wiley-Blackwell.

**Mode of evaluation:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

| | | | |
|---|---|---|---|
| **Recommended by Board of Studies** | 04.03.2016 | | |
| **Approved by Academic Council** | No. 40 | **Date** | 18.03.2016 |

| CLE5005 | DESIGN OF WATER AND WASTEWATER TREATMENT SYSTEMS | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 2 | 0 | 2 | 4 | 4 |
| Pre-requisite | Nil | Syllabus version | | | | |
| | | 1.0 | | | | |

**Course Objectives:**

1. To identify the parameters that characterize the constituents found in potable water and wastewater.
2. To assess the need for water and wastewater treatment.
3. To recognize and illustrate the common physical, chemical and biological unit operations encountered in treatment processes.
4. To understand the most critical issues and challenges in planning, designing, and operating water and wastewater treatment facilities.
5. To know the complete design water and wastewater treatment facilities.
6. To know the ultimate disposal and utilization practices of residuals from water and wastewater treatment units.
7. To obtain the knowledge of various advanced treatment techniques.

**Expected Course Outcome:**

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

1. Interpret the raw and treated water quality data to assess its suitability for potential use in potable or recycled water supply systems and the environment.
2. Evaluate water quality guidelines and regulations to set water quality targets and performance criteria for treatment plant design.
3. Describe suitable treatment processes and develop a water and wastewater management plan.
4. Develop design criteria necessary for water and wastewater treatment unit operations and processes.
5. Design the physical, chemical and biological unit operations involved in water and wastewater treatment.
6. Select the effective residual management system and methods.
7. Design various advanced treatment techniques used in water and wastewater treatment.

| Module: 1 | Municipal Water Supply, Sources Quantity and Quality | 2 hours |
|---|---|---|

Objectives of water treatment, raw water sources and quality, Drinking Water Quality Standards, Regulations, per capita water demand, Population Estimates – Guide to Selection of Water Treatment Processes, water distribution network

| Module: 2 | Conventional Unit Operations used in Water Treatment | 4 hours |
|---|---|---|

Aeration, types of settling, principal of sedimentation, sedimentation tank design, coagulation, flocculation, filtration, rapid gravity sand filter, multimedia filter, disinfection, mechanism of disinfection, chlorine, other disinfectants

| Module: 3 | Wastewater Characterization and Disposal | 3 hours |
|---|---|---|

Philosophy of wastewater treatment, characteristics of wastewater, discharge standards for aquatic and land disposal, Wastewater Disposal; disposal to inland waters such as lakes reservoirs, rivers

| | | |
|---|---|---|
| and streams, disposal to sea, disposal on Land. | | |
| **Module: 4** | **Pre- and Primary Wastewater Treatment** | **4 hours** |
| Quantity of wastewater generated, collection of wastewater, flow variation, design of stabilization plant, preliminary treatment methods. | | |
| **Module: 5** | **Secondary Wastewater Treatment** | **5 hours** |
| Attached growth system, design of trickling filter, RBC, Suspended growth system, design of activated sludge process (ACP), variations of ACP, wastewater treatment pond, requirements of tertiary treatment, different advanced wastewater treatments. | | |
| **Module: 6** | **Advanced Unit Operations used in Water and Wastewater Treatment** | **5 hours** |
| Ion exchange, advanced filtration and adsorption, microfiltration, ultrafiltration, activated carbon, softening, reverse osmosis. | | |
| **Module: 7** | **Residual Management** | **5 hours** |
| Quantity of residual from water and wastewater treatment, physical and chemical characteristics of Residuals –residual management, thickening – stabilization – conditioning – dewatering – oxidation –incinaration - ultimate disposal and utilization of Solids. | | |
| **Module: 8** | **Contemporary issues** | **2 hours** |
| Technology Current / Contemporary Issues / Guest Lectures etc., | | |
| **Total Lecture hours** | | **30 hours** |

**Text Book(s)**

1. 'Water and Wastewater Engineering: Design Principles and Practice' authored by Mackenzie L. Davis, McGraw-Hill Education (India) Private Ltd., 2015 (ISBN-13: 978-1-25-906483-8).
2. 'Water Treatment: Principles and Design' authored by John C. Crittenden, R. Rhodes Trussell, David W. Hand, Kerry J. Howe and George Tchobanoglous, 3rd Edition, John Willey and Sons, 2012 (ISBN: 978-0-470-40539-0).
3. Handbook of Water and Wastewater Treatment Plants Operations' authored by Frank R. Spellman, 3rd Edition, CRC Press, 2014 (ISBN-13: 978-1-4665-5338-5).

**Reference Books**

1. 'Water Works Engineering: Planning, Design and Operation' authored by Syed R. Qasim, Edward M. Motley and Guang Zhu, Pearson Prentice Hall, 2011 (ISBN: 978-81-203-2153-3).
2. 'Wastewater Treatment Plants: Planning, Design and Operation' authored by Syed R. Qasim, Edward M. Motley and Guang Zhu, 2nd Edition, CRC Press, 2015 (ISBN: 1-56676-688-5).
3. 'Water and Wastewater Calculations Manual' authored by Shun Dar Lin and C. C. Lee, (2007) 2nd Edition, The McGraw-Hill Companies, Inc, (ISBN: 0-07-154266-3).
4. 'Water Treatment Plant Design' by American Water Works Association, (2012), 5th Edition, McGraw - Hill Inc., (ISBN: 978-0-07-174572-7).
5. 'Wastewater Engineering: Treatment and Resource Recovery' authored by Metcalf & Eddy, George Tchobanoglous and Franklin L. Burton, (2013), 5th Edition, The McGraw-Hill Companies, Inc, (ISBN: 978-0-07-340118-8).

| List of Challenging Experiments (Indicative) | | |
|---|---|---|
| 1. | Prepare a pre-design proposal of water treatment plant for the city / town / village / community you live. | 3 hours |
| 2. | Prepare a mass balance flow of pollution load in water treatment plant for the pre-design proposal you prepared. | 3 hours |
| 3. | Design a water treatment plant for the city / town / village / community you live as in the pre-design proposal you prepared. | 3 hours |
| 4. | Design a rain water harvesting system for the city / town / village / community / apartment / house you live. | 3 hours |
| 5. | Prepare a pre-design proposal of wastewater treatment plant for the city / town / village / community you live. | 3 hours |
| 6. | Prepare a pre-design proposal of wastewater treatment plant for the city / town / village / community you live. | 3 hours |
| 7. | Design a wastewater treatment plant for the city / town / village / community you live as in the pre-design proposal you prepared. | 4 hours |
| 8. | Prepare a pre-design proposal of wastewater reuse and recycle for the city / town / village / community / house you live. | 4 hours |
| 9. | Design a wastewater reuse and recycle system for the city / town / village / community / house you live as in the pre-design plan you prepared. | 4 hours |
| | | **30 hours** |
| **Project Titles (J component)** | | |
| Challenging projects for Individual or a group will be given based on the basic and advancements in the course content | | **60 hours** |
| **Mode of assessment:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test | | |

| | | | |
|---|---|---|---|
| **Recommended by Board of Studies** | 04.03.2016 | | |
| **Approved by Academic Council** | No. 40 | **Date** | 18.03.2016 |

| CLE5007 | ENVIRONMENTAL QUALITY MONITORING | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 3 | 0 | 2 | 0 | 4 |
| **Pre-requisite** | **Nil** | **Syllabus version** | | | | |
| | | 1.1 | | | | |

**Course Objectives:**

1. To provide an overall understanding of the environment.
2. To understand the sampling techniques.
3. To analyze the physicochemical and microbial qualities of water and wastewater.
4. To know the sampling and analysis of water, air and soil.
5. To understand the standard methodologies for sampling and analysis of samples.
6. To learn the working principles of various instruments used in environmental analysis.

**Expected Course Outcome:**

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

1. Understand the sampling techniques.
2. Analyze the physicochemical and microbial qualities of water and wastewater.
3. Perform the sampling and analysis of water, air and soil.
4. Analyse particulates and chemical air pollutant.
5. Understand the standard methodologies for sampling and analysis of samples.
6. Examine the working principles of various instruments used in environmental analysis.

| **Module: 1** | **General Sampling and Analytical Techniques** | **7 hours** |
|---|---|---|

General principles for collection of representative sample, frequency of sampling, validation, interpretation and analysis of data, various statistical techniques, quality control, assessment and management.

| **Module: 2** | **Physicochemical Analysis of Water / Wastewater** | **7 hours** |
|---|---|---|

Gravimetric methods for water and wastewater, determination of various physicochemical parameters, working principles of electrodes, different types of electrodes.

| **Module: 3** | **Biological Methods and Microbiology** | **5 hours** |
|---|---|---|

Biochemical oxygen demand (BOD), MPN test for microbial pollution, plate counts; confirmatory tests for various microbiological agents.

| **Module: 4** | **Air Pollution Measurements** | **6 hours** |
|---|---|---|

Sampling techniques for air pollution measurements; analysis of particulates and common chemical air pollutants, analysis of oxides of nitrogen, oxides of sulphur, carbon monoxide, hydrocarbon and poly aromatic hydro carbons.

| **Module: 5** | **Spectroscopic methods** | **6 hours** |
|---|---|---|

Principles, techniques and applications of spectrophotometry, fluorimetry, nephelometry and turbidimetry, Atomic Absorption Spectrometry, Atomic Emission Spectrometry, Inducted Coupled Plasma (ICP) – TOC Analyzer.

| **Module: 6** | **Chromatographic methods** | **6 hours** |
|---|---|---|

Principles, techniques and applications of GC, GC-MS, High performance liquid chromatography (HPLC) and Ion chromatograph (IC)-Hyphenated techniques for Environmental contaminant (trace organics) analysis.

| Module: 7 | Continuous monitoring instruments | 6 hours |
|---|---|---|
| Principles, techniques and applications of NDIR analyzer for CO, chemiluminescent analyzer for NOx, Fluorescent analyzer for SO2- Particulates analysis- Auto analyzer for water quality using flow injection analysis. | | |
| **Module: 8** | **Contemporary issues** | **2 hours** |
| Technology Current / Contemporary Issues / Guest Lectures etc., | | |
| **Total Lecture hours** | | **45 hours** |

**Text Book(s)**

1. Clair N Sawyer, Perry L. McCarty and Gene F. Parkin (2002), Chemistry for Environmental Engineering and Science, McGraw-Hill Science.
2. Reeve, R.N. (2010) "Introduction to Environmental Analysis", John Wiley & Sons, Chichester, UK.

**Reference Books**

1. Stanley E. Manahan (2017), Environmental Chemistry, 10th Edition, CRC Press.
2. Maier, R. M., I. L. Pepper and C. P. Gerba, (2008) "Environmental Microbiology", Academic Press, New York.

| **List of Challenging Experiments (Indicative)** | | |
|---|---|---|
| 1. | Determination of pH and drawing pH-mV relation | 2 hours |
| 2. | Determination of EC and turbidity | 2 hours |
| 3. | Determination of oil and grease | 2 hours |
| 4. | Determination of hardness and alkalinity | 2 hours |
| 5. | Determination of Chlorides and Sulfates | 2 hours |
| 6. | Determination of available chlorine in bleaching powder and residual Chlorine | 2 hours |
| 7. | Determination of suspended, settleable, volatile and fixed solids | 2 hours |
| 8. | Determination of optimum dosages of various coagulants | 2 hours |
| 9. | Determination of dissolved Oxygen and BOD | 2 hours |
| 10. | Determination of COD from given sample | 2 hours |
| 11. | Determination of RSPM and PM10 | 2 hours |
| 12. | Determination of SOx and NOx in ambinet air | 2 hours |
| 13. | Physico Chemical analysis of various soil samples | 2 hours |
| 14. | Determination of nitrogen compounds | 2 hours |
| 15 | Determination of MPN Index | 2 hours |
| **Total** | | **30 hours** |

**Mode of assessment:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

| **Recommended by Board of Studies** | 27.09.2017 | | |
|---|---|---|---|
| **Approved by Academic Council** | No. 47 | **Date** | 05.10.2017 |

| MEE5018 | RENEWABLE ENERGY TECHNOLOGIES | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 2 | 0 | 2 | 4 | 4 |
| **Pre-requisite** | **Nil** | **Syllabus version** | | | | |
| | | 1.0 | | | | |

**Course Objectives:**

1. To understand the importance of various Renewable Energy Technologies
2. To obtain knowledge on the energy conversion techniques employed for various renewable Energy sources
3. To know the limitations involved on the conversion efficiency of different renewable energy sources
4. To apply knowledge on how to assess the performance of a renewable energy based system using fundamentals of physics and chemistry

**Expected Course Outcome:**

At the end of the course, the students will be able to

1. Understand the physical process involved in energy conversion of renewable sources for different applications
2. Explain the working principles of different renewable energy based systems.
3. Identify various parameters that influence the performance of devices/processes.
4. Understand the solar photovoltaic cell manufacturing techniques and the components that are present in the photovoltaic system
5. Design a bio-gas anaerobic digester for the specific requirement using different raw materials
6. Understand the site requirement for small hydro power plant and choose respective turbines based on head available
7. Select energy conversion methods for deriving power from oceans such as wave, tidal and OTECs

| **Module: 1** | **Classification of Energy** | **5 hours** |
|---|---|---|

Energy chain and common forms of usable energy- Present energy scenario-World energy status-Energy scenario in India - Introduction to renewable energy resources - Introduction to Solar Energy-Energy from sun-Spectral distribution of Solar radiation- Instruments for measurement of solar radiation-Solar radiation data analysis

| **Module: 2** | **Applications of Solar Energy** | **6 hours** |
|---|---|---|

Thermal applications -Introduction to Solar thermal collectors- Types - Principle of operation of different collectors - Flat plate- Evacuated tube collectors-Compound parabolic collectors- Solar air heaters - Solar dryers-solar cookers- solar stills - Solar ponds - concentrating collectors- line type - point type - Methods of Solar power generation - Power towers

| **Module: 3** | **Introduction to Solar Photovoltaics** | **5 hours** |
|---|---|---|

Physics of solar cells - Cell and module

**Manufacturing Process:**

Characteristics of cells and module - Performance parameters -BoS- PV System applications - Stand alone- Grid connected systems

| | | |
|---|---|---|
| **Module: 4** | **Bio Energy Sources** | **4 hours** |
| Energy through various processes - Energy through fermentation - Gasification - various types of gasifiers - Pyrolysis - Fixed bed and fast Pyrolysis - Bio energy through digestion - Types of Digesters - Factors affecting the yield of products | | |
| **Module: 5** | **Wind Energy** | **4 hours** |
| Resource assessment - types of wind turbines - selection of components - blade materials - power regulation - various methods of control - wind farms - site selection - off shore wind farms - Solar Wind Hybrid energy systems. | | |
| **Module: 6** | **Small Hydro Power Systems** | **2 hours** |
| Introduction - types - system components, discharge curve and estimation of power potential - Turbines for SHP | | |
| **Module: 7** | **Ocean and Geothermal Energy** | **2 hours** |
| Power generation through OTEC systems - various types - Energy through waves and tides - Energy generation through geothermal systems – types | | |
| **Module: 8** | **Contemporary issues** | **2 hours** |
| | **Total Lecture hours** | **30 hours** |

**Text Book(s)**

1. John Andrews, Nick Jelley, Energy Science: Principles, technologies and impacts (2013), Oxford Universities press.
2. Godfrey Boyle, Renewable Energy, power for a sustainable future (2012), Oxford University Press.
3. Fang Lin You, Hong ye, Renewable Energy Systems, Advanced conversion technologies and applications (2012) CRC Press.

**Reference Books**

1. John. A. Duffie, William A. Beckman, Solar Engineering of Thermal processes (2013), Wiley.
2. Jha A. R., Wind Turbine technology (2010) CRC Press.
3. Chetan singh solanki, Solar Photovoltaics, fundamentals, technologies and applications (2011), Prentice Hall India.

**Mode of evaluation:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

**List of Challenging Experiments (Indicative)**

**Practical Challenging Experiments**

| | | |
|---|---|---|
| 1. | Estimation of Solar radiation : Pyranometer, pyrheliometer | 3 |
| 2. | Production of Hydrogen from Electrolysis with PV system. | 3 |
| 3. | Testing the yield of a Solar still in outdoor conditions(Multiple sessions) | 3 |
| 4. | Wind Energy Experimental Set up – I | 3 |
| 5. | Wind Energy Experimental Set up – II | 3 |
| 6. | Testing of Solar PV system in PV training Kit | 3 |

| | | |
|---|---|---|
| 7. | Fuel Cell Experiment | 4 |
| 8. | Performance of Biomass stove | 4 |
| 9. | Flash Point and Fire point comparison for conventional fuels and alternate fuels. | 4 |
| **Total** | | **30 hours** |
| **J Component** | | |
| 1. | Generally a team project of Five | |
| 2. | Concepts studied in Modules should have been used | |
| 3. | Down to earth application and innovative idea should have been attempted | |
| **Sample Projects** | | |
| 1. | Development of software tools for estimation / calculation of solar energy (apps / Front end tool etc.) | |
| 2. | Development of a Solar cooker with energy storage using scrap materials | |
| 3. | Design and develop a Solar Lantern with suitable energy storage | |
| 4. | Development of a solar thermo electric cooling system | |
| 5. | Design of a smart grid involving various RE technologies | |
| 6. | Resource assessment (Wind/Solar/Biomass energy) | |
| 7. | Estimation of Solar radiation through ANN involving various atmospheric factors | |
| 8. | Tracking mechanism for any solar thermal concentrating device – cooker, Dish, PTC, etc. | |
| 9. | Energy and Energy analysis of any renewable energy device – Based on Solar, Wind, Bio-mass, etc | |
| 10. | Analysis of any renewable energy device using TRNSYS | |
| 11. | Making and characterizing a DSSC solar cell. (Sun Simulator and IV measurement apparatus id required) | |
| 12. | Design and analysis of any Hybrid power generation system. | |
| 13. | Performance comparison of different renewable energy devices. | |
| **Project Titles (J component)** | | **60 hours** |
| **Mode of assessment:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test | | |

| | | | |
|---|---|---|---|
| **Recommended by Board of Studies** | 04.03.2016 | | |
| **Approved by Academic Council** | No. 40 | **Date** | 18.03.2016 |

| MEE5019 | ENERGY AUDIT, CONSERVATION AND MANAGEMENT | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 4 | 4 |
| | | Syllabus version | | | | |
| Pre-requisite | Nil | 1.0 | | | | |

**Course Objectives:**

1. To enable students to gain essential and basic knowledge of various energy forms, its availability and the challenges faced by current way of energy exploitation.
2. To familiarize the students with the procedures of energy auditing and the equipment used for the same.
3. To make students understand the common energy using systems or equipment in commercial and industrial premises
4. To enable the students to apply the knowledge of engineering thermodynamics, energy conversions etc. to come up with energy saving potentials in industrial systems
5. To gain knowledge of applying financial appraisal techniques to energy saving projects.

**Expected Course Outcome:**

Upon completion of this course the student shall be able to

1. Explain the various energy forms, energy consumption systems, and different units of expressing energy.
2. Assess the professional energy audit procedure and standard format of audit reporting.
3. Evaluate the energy consumption, identify the energy saving options and techniques.
4. Analyse the energy conversion in various systems to evaluate its operating efficiency and arrive at energy saving opportunities.
5. Evaluate economic analysis of financial viability of the project

| Module: 1 | Energy scenario | 5 hours |
|---|---|---|

Indian Energy Scenario – Types & Forms of Energy – An overview of energy consumption and its effects – Reasons to save energy (financial and environmental) - Energy Conservation Acts and related policies– Schemes of Bureau of Energy Efficiency (BEE)

| Module: 2 | Energy auditing and management | 5 hours |
|---|---|---|

Definition & objective of Energy management – Energy Audit – Types & Methodology– Energy audit report format – Instruments – Organizational background desired for energy management – Case studies of energy audit in different industries

| Module: 3 | Energy costs and Financial analysis | 7 hours |
|---|---|---|

Understanding Energy Costs – Benchmarking and Energy Performance – Fuel and Energy Substitution – Material Balances – Energy Balances–Financial techniques for assessing energy conservation measures – Fixed and variable cost – Interest charges – Simple payback period – Net Present Value - Discounted cash flow method

| Module: 4 | Principles of Fuels and Combustion | 7 hours |
|---|---|---|

Fuels and combustion– Stoichiometry – Combustion Principles– Boilers (classification, types, working principle of important types) – Boiler Heat Loss Estimation – Furnaces – Insulation & Refractories

| | | |
|---|---|---|
| **Module: 5** | **Energy Efficiency and Economics** | **7 hours** |
| Steam systems – Steam Traps – Cogeneration – Principles & Operation – Waste Heat Recovery – Sources & Grades – Types ( Heat Wheel, Recuperators, Regenerators ,Heat Pipe etc ) – Economics of WHR Systems | | |
| **Module: 6** | **Electrical energy usage** | **7 hours** |
| Electricity Billing –Components & Costs – Determination of kVA demand & Consumption– Time of Day Tariff – Power Factor– Electrical systems – Electric motors | | |
| **Module: 7** | **Energy Efficiency in Electrical Utilities** | **5 hours** |
| Fans & blowers – Compressed air systems – Refrigeration and air conditioning systems - Pumps & pumping systems – Lighting systems – Energy efficient technologies in electrical systems | | |
| **Module: 8** | **Contemporary issues** | **2 hours** |
| **Total Lecture hours** | | **45 hours** |
| **Project Titles (J component) (2, 4, 9)** | | **60 hours** |
| Challenging projects for Individual or a group will be given based on the basic and advancements in the course content. | | |

**Text Book(s)**

1. Smith CB (2015) Energy Management Principles, Pergamon Press, New York.
2. T. D. Eastop and D.R. Croft (1996), Energy Efficiency for Engineers and Technologists, Longman Harlow.

**Reference Books**

1. LC Witte, PS Schmidt and DR Brown (1998): Industrial Energy Management and Utilization, Hemisphere Publishing Corporation, Washington.

**Mode of assessment:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

| | | | |
|---|---|---|---|
| **Recommended by Board of Studies** | 04.03.2016 | | |
| **Approved by Academic Council** | No. 40 | **Date** | 18.03.2016 |

| CLE6005 | SOLID AND HAZARDOUS WASTE MANAGEMENT | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 0 | 3 |
| Pre-requisite | Nil | Syllabus version | | | | |
| | | 1.1 | | | | |

**Course Objectives:**

1. To gain insight into the collection, transfer, and transport of municipal solid waste
2. To understand the design and operation of a municipal solid waste landfill
3. To study the design and operation of a resource recovery and waste-to-energy facility
4. To evaluate the production, clean up and disposal of hazardous wastes
5. To Sample and characterize the solid and hazardous waste
6. To Understand the health and environmental issues related to solid and hazardous wastes
7. To Apply the steps in waste reduction at source, collection techniques, resource recovery / recycling, transport and disposal options

**Expected Course Outcome:**

Upon completion of this course the student shall be able to

1. Explain the collection, transfer, and transport of municipal solid waste
2. Understand the design and operation of a municipal solid waste landfill
3. Design the operation of a resource recovery and waste-to-energy facility
4. Evaluate the production, cleanup and disposal of hazardous wastes
5. Sample and characterize the solid and hazardous waste
6. Understand the health and environmental issues related to solid and hazardous wastes
7. Apply the steps in waste reduction at source, collection techniques, resource recovery / recycling, transport and disposal options

| Module: 1 | Fundamentals of Solid Waste Management | 7 hours |
|---|---|---|

Definition of solid wastes – types of solid wastes – Sources - Industrial, mining, agricultural and domestic – Characteristics. Solid waste Problems - impact on environmental health – Concepts of waste reduction, recycling and reuse.

| Module: 2 | Collection and Transport of Municipal Solid Waste | 7 hours |
|---|---|---|

Determination of composition of MSW – storage and handling of solid waste – Future changes in waste composition. Waste collection systems, analysis of collection system – alternative techniques for collection system. Need for transfer operation, transport means and methods, transfer station types and design requirements.

| Module: 3 | Process of Solid Waste and Energy recovery | 5 hours |
|---|---|---|

Unit operations for separation and processing, Materials Recovery facilities, Waste transformation through combustion and aerobic composting, anaerobic methods for materials recovery and treatment – Energy recovery – Incinerators.

| Module: 4 | Air Pollution Measurements | 5 hours |
|---|---|---|

Land farming, deep well injections. Landfills: Design and operation including: site selection, Geo-environmental investigations , engineered sites, liners and covers, leachate control and treatment, gas recovery and control, including utilization of recovered gas (energy), and landfill monitoring and reclamation.

| Module: 5 | Integrated Waste Management | 7 hours |
|---|---|---|
| Requirements and technical solution designated waste landfill remediation, Integrated waste management facilities. TCLP tests and leachate studies. Economics of the on-site v/s off site waste management options. Natural attenuation process and its mechanisms. Hazardous waste – legislations – RCRA process – superfund process – toxicological principles – dose response – toxic effects – toxic response-Various industrial hazardous waste (textiles, tanneries, electroplating, distilleries etc.) disposal and handling methods-case studies. | | |
| **Module: 6** | **Chemistry of organic and inorganic hazardous waste** | **6 hours** |
| Elements – organic compounds – hydrocarbons – organo- oxygen compounds – nitrogen-sulfur-phosphorus-PCB's – dioxins – asbestos – inorganic compounds – organometallic compounds- Hazard identification – exposure assessment – pathway identification – fate and transport parameters – toxicity values of carcinogenic and non-carcinogenic compounds. | | |
| **Module: 7** | **Biomedical, radiation risk assessment and e - Waste Management** | **6 hours** |
| Biomedical waste: Definition, sources, classification- infectious wastes – handling – storing and disposal of medical wastes – collection, segregation Treatment and disposal- principles of radiation protection – quantifying and combining risks – uncertainty assessments – site specific considerations-E-Waste characteristics, generation, collection, transport and disposal. | | |
| **Module: 8** | **Contemporary issues** | **2 hours** |
| | **Total Lecture hours** | **45 hours** |

**Text Book(s)**

1. Vesilind P.A., Worrell W and Reinhart, Solid waste Engineering, 2nd Edition (2011), C L Engineering.
2. George Tchobanoglous, Hilary Theisen and Samuel A, Vigil (1993), "Integrated Solid Waste Management, Mc-Graw Hill International edition, New York.

**Reference Books**

1. Michael D. LaGrega, Philip L Buckingham, Jeffrey C. E vans (2010), "Hazardous waste Management", Waveland PrInc.
2. CPHEEO (2000), "Manual on Municipal Solid waste management, Central Public Health and Environmental Engineering Organisation, Government of India, New Delhi.
3. Paul T Williams (2013), Waste Treatment and Disposal, 2nd Edition Wiley.

**Mode of assessment:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

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|---|---|---|---|
| **Recommended by Board of Studies** | 27.09.2017 | | |
| **Approved by Academic Council** | No. 47 | **Date** | 05.10.2017 |

| CLE6006 | ENVIRONMENTAL GEOTECHNOLOGY | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 0 | 3 |
| **Pre-requisite** | **Nil** | **Syllabus version** | | | | |
| | | 1.1 | | | | |

**Course Objectives:**

1. To provide an exposure to the geotechnical nature of environmental problems
2. To impart knowledge in the selection of sites for waste disposal using current methodologies
3. To understand transport phenomena in saturated and partially saturated porous media
4. To outline the remediation of hazardous waste and contaminated soil.
5. To obtain knowledge on soil testing methods and ground modification techniques

**Expected Course Outcome:**

Upon completion of this course the student shall be able to

1. Apply the principles of geotechnical engineering aspects in waste disposal.
2. Choose suitable site for waste disposal.
3. Select the suitable liner materials for protecting the ground and groundwater from leachates.
4. Demonstrate the remediation of hazardous waste and contaminated soil.
5. Employ suitable soil testing methods and ground improvement techniques for contaminated site.

| **Module: 1** | **General Sampling and Analytical Techniques** | **7 hours** |
|---|---|---|

Environmental cycles and their interaction, Soil water environment interaction relating to geotechnical problems, Effect of population on soil, water behaviour.

| **Module: 2** | **Physicochemical Analysis of Water / Wastewater** | **7 hours** |
|---|---|---|

Criteria for selection of sites for wastes disposal current methodologies for waste disposal, Sub surface disposal techniques, Passive containment Systems, Leachate movement, application of geomembranes and other techniques in solid and liquid waste disposal. Landfill – Types and design.

| **Module: 3** | **Biological Methods and Microbiology** | **5 hours** |
|---|---|---|

Transport phenomena in saturated and partially saturated porous media – contaminant migration and contaminant hydrology, Hydrological design for ground water pollution control, Ground water pollution downstream of landfills- pollution of aquifers by mining and liquid wastes – protection of acquifers.

| **Module: 4** | **Air Pollution Measurements** | **6 hours** |
|---|---|---|

Hazardous waste control and storage system – stabilization / solidification of waste, Monitoring and performance of waste facilities – safe disposal of solid and Dynamic response of soil under environmental stress.

| **Module: 5** | **Remediation of contaminated soil** | **7 hours** |
|---|---|---|

Approach to remediate soils – attenuation – ex-situ and in situ remediation – S/S technique – bioremediation – incineration – washing – electrokinetics – soil heating – vitrification – bioventing and other methods

| | | |
|---|---|---|
| **Module: 6** | **Chromatographic methods** | **6 hours** |
| Ground modification techniques in waste remedial measures for contaminated grounds, remediation technology, Bio-remediation. | | |
| **Module: 7** | **Detecting and Testing methods** | **5 hours** |
| Methodology – current soil testing methods – approach for characterization and identification of contaminated ground soil for engineering purposes. | | |
| **Module: 8** | **Contemporary issues** | **2 hours** |
| **Total Lecture hours** | | **45 hours** |

**Text Book(s)**

1. Lakshmi Reddi, Hilary I. Inyang, (2000), "Geoenvironmental Engineering: Principles and Applications", CRC Press, New York.
2. Hsai-Yang Fang, (2009), "Introduction to Environmental Geotechnology", CRC Press, New York.

**Reference Books**

1. Wentz, C.A., (2006), "Hazardous Waste Management", McGraw Hill, Singapore.
2. Daniel, D. E., (2012), "Geotechnical practice for waste disposal", Chapman and Hall, London.
3. Ott, W.R., (2008), "Environmental Indices", Theory and Practice, Ann, Arbor, 2008.
4. Raymond N. Yong, (2000) Geoenvironmental Engineering: Contaminated Soils, Pollutant Fate, and Mitigation, CRC Press, New York.

**Mode of assessment:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

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|---|---|---|---|
| **Recommended by Board of Studies** | 27.09.2017 | | |
| **Approved by Academic Council** | No. 47 | **Date** | 05-10-2017 |

| CLE6007 | ENERGY, ENVIRONMENT AND CLIMATE CHANGE | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 0 | 3 |
| **Pre-requisite** | **Nil** | **Syllabus version** | | | | |
| | | 1.1 | | | | |

**Course Objectives:**

1. The Earth's Energy Budget, Environment and the processes leading to climate change.
2. The inter-relatedness of the Terrestrial Energy-Environment-Climate System.
3. The perturbing effects of anthropogenic activities on this system.
4. A meaningful climate change quantification and hence the means of ameliorating adverse climate change impacts.

**Expected Course Outcome:**

Upon completion of this course the student shall be able to

1. Understand the terrestrial eco-system comprising of 3 principal components: Energy, Environment and Climate Change
2. Comprehend a global picture of the inter-relatedness of the Energy-Environment-Climate system
3. Assess as qualified professionals, the perturbing effects of human activities on the earth's climate
4. Predict emerging climate change trends globally as well as within the Indian Subcontinent
5. Understand environmental impacts on a local, regional and global scale.
6. Implement the policies at the decision-making level on the use and appropriateness of extant technologies.

| **Module: 1** | **Introduction** | **5 hours** |
|---|---|---|

Overview on the Earth's energy requirement vis-à-vis Climate Change. Origins of the terrestrial atmosphere. Earth's early atmosphere. Introduction to Climate. Layers of the atmosphere.

| **Module: 2** | **Global Atmospheric Issues** | **6 hours** |
|---|---|---|

Composition of the present day atmosphere. Introduction to Atmospheric chemistry, Green House Gases, and the O3 depletion problem. Post Industrial Revolution Scenario.

| **Module: 3** | **Energy Balance** | **7 hours** |
|---|---|---|

Earth –Atmosphere System. Solar and Terrestrial Radiation. Absorption of Radiation by gases. Energy balance. Solar variability and the Earth's Energy Balance.

| **Module: 4** | **Atmospheric Chemistry and Climate** | **6 hours** |
|---|---|---|

The Global Temperature Record. Possible effects of Global Warming. – Indian Context. Atmospheric Chemistry and Climate Change. Atmospheric Aerosol and Cloud Effects on Climate.

| **Module: 5** | **Environmental Variability** | **5 hours** |
|---|---|---|

Natural (volcanoes, forest fires) and Anthropogenic (Antarctic Ozone Hole, Global Warming). Green House Gas theory. Effects of urbanization, Landscape changes, Influence of Irrigation, Desertification and Deforestation.

| | | |
|---|---|---|
| **Module: 6** | **Safeguarding Future Climate** | **5 hours** |
| The role of International Bodies. Kyoto and Montreal Protocol. Intergovernmental Panel on Climate Change (IPCC). | | |
| **Module: 7** | **Energy Management** | **8 hours** |
| The Stern Report- Carbon Credits- Indian Context- Alternative Energy Sources: Solar, Wind, Hydro Power and Nuclear Energy. Predicting Future Climate Change: Global Climate Models. Use of satellite data to estimate energy balance and climate parameters. | | |
| **Module:8** | **Contemporary issues** | **3 hours** |
| **Total Lecture hours** | | **45 hours** |

**Text Book(s)**

1. Peter E Hodgson (2010), Energy, the Environment and Climate Change, Publisher: Imperial College Press.
2. Richard Wolfson, (2011), Energy, Environment, and Climate, Publisher: W. W. Norton & Company; 2nd Edition.

**Reference Books**

1. Wilbanks, T., Bilello, D., Schmalzer, D., & Scott, M. (Lead Authors). (2013). Climate Change and Energy Supply and Use: Technical Report for the U.S. Department of Energy in Support of the National Climate Assessment. Washington, DC: Island Press.
2. Frank T. Princiotta,(2011), Global Climate Change - The Technology Challenge, Publisher: Springer.

**Mode of assessment:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

| | | | |
|---|---|---|---|
| **Recommended by Board of Studies** | 27.09.2017 | | |
| **Approved by Academic Council** | No. 47 | **Date** | 05-10-2017 |

| CLE6008 | ENVIRONMENTAL IMPACT ASSESSMENT | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 0 | 3 |
| Pre-requisite | | Syllabus version | | | | |
| | | 1.1 | | | | |

**Course Objectives:**

1. To understand the concepts of EIA and also emphasis the role of engineers in EIA and Environmental impact factors.
2. To know the legislations to be used for enforcement of environmental acts and the role of public participation
3. To discuss the methods to be used in EIA and legal systems related to environmental management systems (EMS) (EIA, Environmental Audit (EA), Life cycle Assessment (LCA)) for cleaner production and sustainable development.
4. To know the impacts occurred to physical environment by the projects
5. To know the impacts occurred to biological environment by the projects
6. To know the impacts occurred to human resources by the projects
7. To draft a EIA for specific projects and understanding the mitigation and monitoring methods
8. To get exposed to practical experience for drafting a EIA through consultant / Government

**Expected Course Outcome:**

Upon completion of this course the student shall be able to

1. Explain the philosophy and art of environmental management systems
2. Understand the role of government in approving the projects and the laws to be enforced
3. Apply the mechanism of EIA for Project Appraisal, Decision making and Implementation
4. Identify the methods in handling the data collected during the EIA processes
5. Understand the impacts that could occur for physical, biological and human resources by the project
6. Draft complete EIA report
7. Assess environmental assessments and auditing
8. Differentiate between theory and practice for writing a EIA report

| Module: 1 | General Sampling and Analytical Techniques | 6 hours |
|---|---|---|

EIA for Environmental Engineers–Environmental Impact Statement – Environmental Appraisal–Environmental Impact Factors.

| Module: 2 | EIA Legislation | 6 hours |
|---|---|---|

Criteria and Standards for Assessing Significant Impacts – Risk Assessment – Public Participation and Involvement.

| Module: 3 | EIA Process and Methods | 9 hours |
|---|---|---|

Criteria for the Selection of EIA Methodology – Screening – Scoping – Predictive Models for Impact Assessment – Mitigation, Monitoring, Auditing, Evaluation of Alternatives and Decision Making –Methods of Strategic Environmental Assessment. Environmental management plan.

| Module: 4 | Prediction and Assessment of Impacts on Physical Environment | 6 hours |
|---|---|---|

Geology –Soils – Minerals – Climate – Water Resources – Water Quality – Air Quality – Noise.

| | | |
|---|---|---|
| **Module: 5** | **Prediction and Assessment of Impacts on Biological Environment** | **5 hours** |
| Terrestrial Ecosystems – Wetland Ecosystems – Aquatic Ecosystems – Threatened and Endangered Species. | | |
| **Module: 6** | **Prediction and Assessment of Impacts on Human Resources** | **6 hours** |
| Demographics – Economics – Land Use – Infrastructure – Archaeological and Historic – Visual – Safety. | | |
| **Module: 7** | **EIA Case Studies** | **5 hours** |
| Environmental Impact of Industrial Development –Management Requirements for the Preparation of EIA for industrial projects –Preparation of EIA of Land Clearing Projects – Assessment of Impacts of Traffic and Transportation – EMP. | | |
| **Module: 8** | **Contemporary issues** | **2 hours** |
| | **Total Lecture hours** | **45 hours** |

**Text Book(s)**

1. 'Environmental Impact Assessment' authored by Larry W. Canter, 1st Edition, McGraw-Hill, Inc., 1996 (ISBN: 0-07-009767-4).
2. 'Methods of Environmental Impact Assessment' Edited by Peter Morris and Riki Therivel, 3rd Edition, Routledge - Taylor & Francis Group, 2009 (ISBN: 0-203-89290-9).
3. 'Environmental Impact Assessment Methodologies' authored by Y. Anjaneyulu and Valli Manickam, 2nd Edition, B.S. Publications, 2007 (ISBN: 978-81-7800-144-9).

**Reference Books**

1. 'Handbook of Environmental Impact Assessment- Volume 1 & 2' authored by Judith Petts, Blackwell Science Ltd., 1999 (ISBN 0-632-04772-0; ISBN 0-632-04771-2).
2. 'Environmental Impact Assessment: Theory and Practice' edited by Peter Wathern, Routledge-Taylor & Francis Group, 2004 (ISBN: 0-203-40997-3).
3. 'Environmental Impact Assessment: A Guide to Best Professional Practices' Edited by Charles H. Eccleston, CRC Press, 2011 (ISBN: 978-1-4398-2873-1).

**Mode of assessment:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

| | | | |
|---|---|---|---|
| **Recommended by Board of Studies** | 27.09.2017 | | |
| **Approved by Academic Council** | No. 47 | **Date** | 05.10.2017 |

| CLE6009 | AIR AND NOISE POLLUTION CONTROL | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 0 | 3 |
| **Pre-requisite** | **Nil** | **Syllabus version** | | | | |
| | | 1.1 | | | | |

**Course Objectives:**

1. To explore the aspects of the science of atmospheric pollution.
2. To learn atmospheric composition, acidic deposition, urban air quality and global changes in the atmosphere.
3. To distinguish between various methods of air pollution monitoring and analysis.
4. To study the use of models in air pollution studies.
5. To understand the sources, effects and measurement methods of noise pollution.
6. To identify, formulate and solve air and noise pollution problems.

**Expected Course Outcome:**

Upon completion of this course, the student will be able

1. Describe the main chemical components and reactions in the atmosphere.
2. Classify established methods for monitoring and modeling spatial and temporal patterns of pollution.
3. Assess the environmental impacts of atmospheric pollution.
4. Analyze the effect of air and noise pollution.
5. Evaluate the scientific basis underlying in controlling of air pollutants.
6. Select suitable measures for noise pollution control.

| **Module: 1** | **General Sampling and Analytical Techniques** | **4 hours** |
|---|---|---|

Sources and Sinks of Air Pollution–Classification and Scales of the Air Pollution Problems–Source Emission Inventory–Indoor Air Pollution.

| **Module: 2** | **Effects of Air Pollution** | **6 hours** |
|---|---|---|

Effects on Health and Human Welfare–Effects on Vegetation and Animals–Effects on Materials and Structures–Effects on the Atmosphere, Soil and Water Bodies–Long-Term Effects on the Planet.

| **Module: 3** | **Measurement and Monitoring of Air Pollution** | **8 hours** |
|---|---|---|

Personnel, Ambient and Industrial Air Sampling and Monitoring–Analysis and Measurement of Gaseous and Particulate Pollutants.

| **Module: 4** | **Air Pollution Modelling** | **6 hours** |
|---|---|---|

Meteorological Bases of Atmospheric Pollution–Transport and Dispersion of Air Pollutants–Air Pollution Modelling and Prediction.

| **Module: 5** | **Air Quality Legislation and Control** | **7 hours** |
|---|---|---|

Air Quality Criteria and Standards–Elements of Regulatory and Non-regulatory Control–Pollutant Specific Control Devices, Technologies and Systems.

| **Module: 6** | **Basics of Noise Pollution** | **6 hours** |
|---|---|---|

Sound and Noise–Sources of Noise Pollution–Effects of Noise Pollution to Human Health & Welfare and Wildlife–Fundamentals of Sound Generation, Propagation and Measurement–Noise Standards and Regulations.

| Module: 7 | Noise Control and Management | 6 hours |
|---|---|---|
| Noise Prevention and Mitigation Measures–Noise Pollution Control and Management for Community Environmental Noise and Industrial Noise. | | |
| **Module: 8** | **Contemporary issues** | **2 hours** |
| | **Total Lecture hours** | **45 hours** |

**Text Book(s)**

1. 'Fundamentals of Air Pollution' authored by Daniel Vallero, 4th Edition, Elsevier's Science & Technology, 2008 (ISBN: 978-0-12-373615-4).
2. 'Environmental Noise Pollution: Noise Mapping, Public Health, and Policy' authored by Enda Murphy and Eoin A. King, 1st Edition, Elsevier's Science & Technology, 2014 (ISBN: 978-0-12-411595-8).

**Reference Books**

1. 'Air Pollution Control Technology Handbook' authored by Karl B. Schnelle, Jr. and Charles A. Brown, CRC Press, 2002 (ISBN 0-8493-9588-7).
2. 'Air Pollution' authored by Jeremy Colls, 2nd Edition, SPON Press, 2003 (ISBN 0–415–25564–3).
3. 'Principles of Air Quality Management' authored by Roger D. Griffin, 2nd Edition, CRC Press, 2007 (ISBN 0-8493-7099-X).
4. 'Air Pollution Control Engineering' Edited by Lawrence K. Wang, Norman C. Pereira and Yung-Tse Hung, Humana Press Inc, 2004 (ISBN: 1-58829-161-8).
5. 'Advanced Air and Noise Pollution Control' Edited by Lawrence K. Wang, Norman C. Pereira and Yung-Tse Hung, Humana Press Inc, 2005 (ISBN: 1-58829-359-9).
6. 'Noise Control in Industry: A Practical Guide' authored by Nicholas P. Cheremisinoff, NOYES Publications, 1996 (ISBN: 0-8155-1399-2).

**Mode of assessment:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

| | | | |
|---|---|---|---|
| **Recommended by Board of Studies** | 27.09.2017 | | |
| **Approved by Academic Council** | No. 47 | **Date** | 05.10.2017 |

| CLE6010 | ADVANCED WASTEWATER TREATMENT | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 0 | 3 |
| Pre-requisite | Nil | Syllabus version | | | | |
| | | 1.1 | | | | |

**Course Objectives:**

1. To Know about the conventional treatment units and processes
2. To Role of microorganisms in wastewater treatment
3. To understand Biological Nutrients removal
4. To Nutrients removal by chemical process
5. To Wastewater reuse, recycling and disposal of treated effluents

**Expected Course Outcome:**

After the end of the course the student will able to

1. Understand the conventional treatment units and processes.
2. Analyse the role of microorganisms in wastewater treatment.
3. Examine the Biological Nutrients removal.
4. Examine Nutrients removal by chemical process.
5. Demonstrate the Wastewater reuse, recycling and disposal of treated effluents.

| Module: 1 | Importance of Advanced Wastewater Treatment | 5 hours |
|---|---|---|

Effects of chemical constituents in wastewater / Basis of process selection and development of treatment flow sheets.

| Module: 2 | Biological Nutrient Removal | 8 hours |
|---|---|---|

Sources and forms of Nitrogen (N) and Phosphorus (P) / Conventional biological nitrification/ denitrification processes and its process fundamentals. Sequencing Batch Reactor (SBR) and Simultaneous Nitrification – Denitrification (SND) processes for nitrogen removal.

| Module: 3 | Biological Methods and Microbiology | 6 hours |
|---|---|---|

New processes for nitrogen removal: ANAMMOX, SHARON, CANON etc. Biological removal of Phosphorus-Process fundamentals and types of processes. Combined removal of N and P by biological methods

| Module: 4 | Chemical Nutrient Removal | 7 hours |
|---|---|---|

Nitrogen removal by physical and chemical methods- Air stripping of ammonia / Breakpoint Chlorination / Ion – exchange. Removal of phosphorus by chemical addition.

| Module: 5 | Refractory Organics and Dissolved Inorganic Substances Removal | 6 hours |
|---|---|---|

Advanced Oxidation Processes (AOP)/ Adsorption / Chemical precipitation / Ion Exchange / Membrane Processes.

| Module: 6 | Wastewater Reclamation / Reuse / Disposal | 7 hours |
|---|---|---|

Direct and indirect reuse of wastewater- Municipal reuse / industrial reuse / agricultural reuse / recreational reuse / ground water recharge. Criteria and disposal of effluent in to lakes, rivers and ocean. Membrane Bio-Reactor (MBR) applications.

| | | |
|---|---|---|
| **Module: 7** | **Biodegradation** | **4 hours** |
| Microbial degradation of biopolymers and Hydrocarbons – Eco-technologies – Wetland process. | | |
| **Module: 8** | **Contemporary issues** | **2 hours** |
| | **Total Lecture hours** | **45 hours** |

**Text Book(s)**

1. Metcalf & Eddy (2009), Wastewater Engineering- Treatment, Disposal and Reuse, Second edition, Tata McGraw-Hill, New Delhi.
2. Peavy, Rowe &Tchobanoglous (2010), Environmental Engineering, Tata McGraw-Hill, New Delhi.

**Reference Books**

1. 'Wastewater Treatment Plants: Planning, Design and Operation' authored by Syed R. Qasim, Edward M. Motley and Guang Zhu, 2nd Edition, CRC Press, 2015 (ISBN: 1-56676-688-5).
2. 'Water and Wastewater Calculations Manual' authored by Shun Dar Lin and C. C. Lee, 2nd Edition,The McGraw-Hill Companies, Inc, 2007 (ISBN: 0-07-154266-3).
3. Handbook of Water and Wastewater Treatment Plants Operations' authored by Frank R. Spellman, 3rd Edition, CRC Press, 2014 (ISBN-13: 978-1-4665-5338-5).
4. 'Water and Wastewater Engineering: Design Principles and Practice' authored by Mackenzie L. Davis, McGraw-Hill Education (India) Private Ltd., 2015 (ISBN-13: 978-1-25-906483-8).

**Mode of assessment:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

| | | | |
|---|---|---|---|
| **Recommended by Board of Studies** | 27.09.2017 | | |
| **Approved by Academic Council** | No. 47 | **Date** | 05-10-2017 |

| CLE6011 | MATHEMATICAL MODELING IN ENVIRONMENTAL ENGINEERING | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 0 | 3 |
| Pre-requisite | Nil | Syllabus version | | | | |
| | | 1.1 | | | | |

**Course Objectives:**

1. To study the role and nature of modelling environmental processes and systems.
2. To represent mathematically the fate and transport of conservative and non-conservative substances in surface and sub-surface environmental systems.
3. To learn the basic principles of model building using both empirical and mechanistic modelling approaches.
4. To explain the key aspects of the biogeochemical cycles and be able to evaluate the cycles in terms of turn-over-times, steady-state and dynamics.
5. To put up, use, and interpret a mathematical model for material cycling in a given environment and the dynamical aspects of environmental processes and systems.
6. To apply models to evaluate scenarios relevant to pollution control, engineering interventions, and hydro-climatologically variability.

**Expected Course Outcome:**

Upon completion of the course, the students shall be able to:

1. Understand the mathematical models that can be used to solve environmental problems.
2. Select material balance models for conservative and non-conservative systems.
3. Formulate and evaluate boundary value problems.
4. Formulate and evaluate complex Environmental Problems.
5. Interpret the results of modelling within the context of its capabilities and limitations to address critical issues.
6. Analyse the modelling environmental system methods and techniques.

| Module: 1 | Fundamental of Mathematical modeling | 4 hours |
|---|---|---|
| Terminology - Formulation and analysis – Steps in developing – computational methods | | |
| **Module: 2** | **Environmental process and systems** | **6 hours** |
| Phase equilibrium – transport process – reactive and non reactive process – reactors – homogeneous and heterogeneous reactors | | |
| **Module: 3** | **Modeling of homogeneous reactors** | **7 hours** |
| Classification – mixed batch reactors – sequencing batch reactor – mixed flow reactors – plug flow reactors | | |
| **Module:4** | **Modeling of reactors** | **7 hours** |
| Fluid-solid systems – slurry reactor – fluid- fluid system – columns – sparged tanks | | |
| **Module: 5** | **Subsurface environmental system** | **8 hours** |
| Fundamental of modeling soil systems – flow of water through saturated zone – groundwater flow nets – flow of contaminants through saturated and unsaturated zone. Introduction to MODFLOW and | | |

| | | |
|---|---|---|
| ANSYS models. | | |
| **Module: 6** | **Surface environmental system** | **5 hours** |
| Fundamental of modeling aquatic systems – lake systems – steady state concentration – river systems – steady state with and without source or sink –estuary systems | | |
| **Module: 7** | **Water quality modelling** | **6 hours** |
| The unusual qualities of water. Modelling Biochemical Oxygen demand (BOD). Estimating the BOD Reaction Rate Constant. The effect of Oxygen-demanding wastes on rivers. A model for De-oxygenation. The Oxygen-sag curve. | | |
| **Module: 8** | **Contemporary issues** | **2 hours** |
| **Total Lecture hours** | | **45 hours** |

**Text Book(s)**

1. John Wainwright and Mark Mulligan, (2013), "Environmental Modelling Finding Simplicity in Complexity", 2nd edition, John Wiley and sons Ltd, USA.
2. Steven C. Chapra, (2009), Surface Water Quality Modelling, The McGraw-Hill Companies, Inc., New York.

**Reference Books**

Deaton and Wine Brake, (2002), "Dynamic Modelling of Environmental Systems", Wiley & sons.

**Mode of assessment:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

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|---|---|---|---|
| **Recommended by Board of Studies** | 27.09.2017 | | |
| **Approved by Academic Council** | No. 47 | **Date** | 05.10.2017 |

| CLE6012 | REMOTE SENSING AND GIS APPLICATIONS | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 2 | 0 | 2 | 0 | 3 |
| Pre-requisite | Nil | Syllabus version | | | | |
| | | 1.0 | | | | |

**Course Objectives:**

1. To understand the basic concepts of remote sensing.
2. To learn basic concepts of Geo-graphical Information Systems (GIS).
3. To know various applications of Remote Sensing and GIS applications in Civil Engineering
4. To know the importance of decision making system.
5. To understand the importance of Remote Sensing and GIS in Disaster Mitigation and Management.
6. To understand the importance of digital elevation model (DEM) in various water resources engineering applications.

**Expected Course Outcome:**

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

1. Infer the Indian remote sensing satellites and their platforms.
2. Present available GIS and Remote Sensing software like ARC GIS, QGIS and ERDAS Imagine.
3. Develop the Digital Elevation Model (DEM).
4. Analyse the land use and land cover to develop NDVI and EVI
5. Generate of spectral library
6. Understand the Importance of GIS and Remote Sensing in Environmental Management.

| Module: 1 | Basic concepts of Remote sensing | 4 hours |
|---|---|---|

Introduction to Remote Sensing, Electromagnetic Spectram and radiation, Remote Sensing Platforms and Satellite Sensors

| Module: 2 | Sensors and Scanning Systems in Remote Sensing | 4 hours |
|---|---|---|

Indian Remote Satellites (IRS), Spectral characteristics earth surface features i.e, vegetation, water and soil, Understanding the spectral curves to create spectral library. Digital Image processing of satellite data, Elements of photo / image interpretation , Concepts of digital image processing

| Module: 3 | Image Classification | 5 hours |
|---|---|---|

Filters, Image registration, Feature extraction techniques, Image classification, Landuse and landcover analysis

| Module: 4 | Basic concepts of GIS | 4 hours |
|---|---|---|

Introduction to GIS, History of development of GIS, Elements of GIS - Computer hardware and software, Map reading, various maps in GIS. Map overlay and Overlay operations

| Module: 5 | Spatial Analysis tools | 4 hours |
|---|---|---|

Vector and Raster data model, Data storage and database management, Spatial data analysis techniques

| Module: 6 | Data Collection | 4 hours |
|---|---|---|
| Spatial Data Policy, Spatial / Remote Sensing data collection, Open Source GIS, Web-GIS | | |
| **Module: 7** | **Application** | **3hours** |
| Applications of remote sensing and GIS in energy, environmental and resource management, Case studies | | |
| **Module: 8** | **Contemporary issues** | **2 hours** |
| Technology Current / Contemporary Issues / Guest Lectures etc., | | |
| **Total Lecture hours** | | **30 hours** |

**Text Book(s)**

1. Basudeb Bhatta (2011), Remote Sensing and GIS, Oxford University Press, New Delhi, Second Edition, Fourth Impression 2012.
2. Kang-tsung Chang (2015), Introduction to Geographic Information Systems, McGraw-Hill Education; 8th Edition.
3. G S Srivastava (2014), an Introduction to Geoinformatics, McGraw Hill Education (India) Private Limited.

**Reference Books**

1. Paul Wolf, Bon DeWitt and Benjamin Wilkinson (2014), Elements of Photogrammetry with Application in GIS, McGraw-Hill Education; 4th Edition.
2. Thomos Lille sand, Ralph W. Kiefer and Jonathan Chripman (2015), Remote Sensing and Image Interpretation, Wiley Publisher, 7th Edition.
3. Peter A. Burrough, Rachael A. McDonnell and Christopher D. Lloyd (2015), Principles of Geographical Information Systems, Oxford University Press, 3rd Edition.

**List of Challenging Experiments (Indicative)**

| | | |
|---|---|---|
| 1. | Image Registration (Image to Image, Image to Map). | 3 hours |
| 2. | Image Subset / Clipping. | 3 hours |
| 3. | Spectral Signature of various land features | 3 hours |
| 4. | Image Classification from satellite data sets. | 3 hours |
| 5. | Land use and land cover Analysis. | 3 hours |
| 6. | Importing scanned and image file to GIS platform | 3 hours |
| 7. | Digitization, attribute assigning, Raster to Vector formats | 3 hours |
| 8. | Creating Thematic Layers / Maps | 3 hours |
| 9. | Spatial Analysis (Overlay, Buffering etc.). | 2 hours |
| 10. | DEM / DTM generation | 2 hours |
| 11. | Extraction of Topographic parameters (slope, aspects, drainage etc.,) includes map creation. Open Source data access. | 2 hours |
| **Lab Hours** | | **30 hours** |

**Mode of assessment:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

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|---|---|---|---|
| **Recommended by Board of Studies** | 04.03.2016 | | |
| **Approved by Academic Council** | No. 40 | **Date** | 18.03.2016 |

| CLE6013 | OCCUPATIONAL HEALTH AND INDUSTRIAL SAFAETY | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 0 | 3 |
| Pre-requisite | Nil | Syllabus version | | | | |
| | | 1.0 | | | | |

**Course Objectives:**

1. Applying a very wide scholastic education to successfully lead, influence, and accomplish the safety goals and objectives of the industries.
2. Effectively communicating and collaborating inside a different work environment
3. Working in an ethical and professional ways inside the industry

**Expected Course Outcome:**

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

1. Understand techniques, skills, and modern scientific and technical tools necessary for professional practice of occupational safety and health.
2. Identify and solve occupational safety and health problems.
3. Understand professional and ethical responsibility in occupational safety and health.
4. Design and conduct survey/investigations, as well as to analyse and interpret data in the field of occupational safety and health.
5. Demonstrate knowledge of the contemporary issues surrounding occupational safety and Health.

| Module: 1 | Introduction to Safety | 5 hours |
|---|---|---|

Occurrence of accident – sequence – injuries – occupational injuries – industrial accidents – key principles – OSH principles. Environmental management system (EMS)

| Module: 2 | Motivating safety and health | 6 hours |
|---|---|---|

Motivational environment – principles – self motivation – behavior based safety – Heinrich's Domino concept – Benefits of lean and sustainability

| Module: 3 | Identification and Analysis of hazards | 6 hours |
|---|---|---|

Hazard identification – types – reporting system – audits – root cause analysis – job hazard analysis – risk versus cost. Life cycle analysis.

| Module: 4 | Occupational injuries and illness | 8 hours |
|---|---|---|

Bureau of labor statistics – occupational trauma death – injuries – injury and death cost – temperature extremes – ionizing radiation – noise induced hearing loss – vibrations – chemical hazards – flammable combustible liquids – biological monitoring

| Module: 5 | Industrial hygiene and ergonomics | 7 hours |
|---|---|---|

Occupational illness prevention – industrial modes of entry of contaminants – types of air contaminants – exposure monitoring – units of concentration – limits of exposure – ergonomic risk factors – physical work activities and conditions

| Module: 6 | Intervention, control and prevention of accidents | 6 hours |
|---|---|---|

Hazard prevention and control – elimination or substitution – awareness devices – personal protective equipment – safe operating procedures – fleet safety.

| | | |
|---|---|---|
| **Module: 7** | **OSHA compliance** | **5hours** |
| Standards – employer's responsibilities – violations – medical and exposure records – employer liability – worker's compensation | | |
| **Module: 8** | **Contemporary issues** | **2 hours** |
| | **Total Lecture hours** | **45 hours** |

**Text Book(s)**

1. Industrial safety and health for technologist, engineers and managers, David L. Goetsch, 8th Edition, Pearson Publishers, 2014.

**Reference Books**

1. Handbook of environmental health and safety, Vol I & II, Herman Kooren, Michael Bisesi, Jaico Publishing House, 1999.

**Mode of assessment:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

| | | | |
|---|---|---|---|
| **Recommended by Board of Studies** | 04.03.2016 | | |
| **Approved by Academic Council** | No. 40 | **Date** | 18.03.2016 |

| MEE5006 | SOLAR ENERGY TECHNOLOGIES | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 0 | 3 |
| **Pre-requisite** | **Nil** | **Syllabus version** | | | | |
| | | 1.1 | | | | |

**Course Objectives:**

1. To understand the fundamentals of solar energy conversion technologies.
2. To obtain knowledge on the energy utilization techniques employed for various solar thermal energy devices.
3. To know the limitations involved on the conversion efficiency of different solar energy devices.
4. To apply knowledge on how to assess the performance of solar thermal and solar photovoltaic systems using fundamentals of heat transfer and optical properties.

**Expected Course Outcome:**

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

1. Estimate and assess the solar thermal radiation input for the solar thermal collectors and panels
2. Understand the working of solar water heater based on heat transfer analysis.
3. Identify various parameters that influences the performance of devices/processes.
4. Understand the fundamentals of solar air heater based on heat transfer analysis and basics of concentrating collectors.
5. Understand the basics of solar photovoltaic cell and PV cell configurations.
6. Design a standalone PV systems.
7. Develop mini projects based on solar thermal conversion technologies
8. Understand the site requirement for understanding the contemporary issues in solar thermal and solar PV systems.

| **Module: 1** | **Introduction** | **5 hours** |
|---|---|---|
| Solar radiation relations – Radiation on horizontal and tilted surfaces – Extraterrestrial radiation - Estimation of clear sky radiation – Total radiation on fixed sloped surfaces | | |
| **Module: 2** | **Heat transfer** | **6 hours** |
| Heat transfer aspects in solar thermal – Radiation absorbed by a solar collector -Theory of Flat Plate Collectors | | |
| **Module: 3** | **Performance analysis** | **7 hours** |
| Flat Plate Collectors - Mean fluid and plate temperature calculation – Collector performance - numerical simulation | | |
| **Module: 4** | **Solar air heaters** | **7 hours** |
| Theory of solar air heaters – Basics of concentrating collectors | | |
| **Module: 5** | **PV cells** | **7 hours** |
| Characteristics of PV cells and modules – Performance parameters – PV system configurations | | |

| | | |
|---|---|---|
| **Module: 6** | **Modelling** | **6 hours** |
| Battery Modelling a PV system – Sizing of a stand-alone system | | |
| **Module: 7** | **Implementation** | **5 hours** |
| Mini sizing projects – Based on each collector Technology | | |
| **Module: 8** | **Contemporary issues** | **2 hours** |
| | **Total Lecture hours** | **45 hours** |

**Text Book(s)**

1. S. P. Sukhatme and J. K. Nayak (2010), Solar Energy - Principles of Thermal Collection and Storage, 4th Edition, Tata McGraw Hill.
2. D. Yogi Goswami, Frank Krieth and Jan F. Kreider, Principles of Solar Engineering, 2nd Edition, (2000) CRC Press.

**Reference Books**

1. John A. Duffie and William A. Beckman, Solar Engineering of Thermal Process, 3rd Edition, (2013), John Wiley & Sons.
2. Tomas Mark vart, Solar Electricity, 2nd Edition, (2000) John Wiley & Sons.
3. Simon Roberts, Solar Electricity: Practical Guide to Designing and Installing Small Photovoltaic Systems, Prentice-Hall. (1992), Prentice Hall Inc.

**Mode of assessment:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

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|---|---|---|---|
| **Recommended by Board of Studies** | 27.09.2017 | | |
| **Approved by Academic Council** | No. 47 | **Date** | 05.10.2017 |

| MEE5020 | ALTERNATIVE FUELS | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 0 | 3 |
| Pre-requisite | Nil | Syllabus version | | | | |
| | | 1.0 | | | | |

**Course Objectives:**

1. To familiarize the importance of alternative fuels
2. To familiarize the combustion and emission characteristics of various gaseous and liquid alternative fuels
3. To familiarize the adaptability of engines for the application alternative fuels
4. To develop for conversion of waste biomass into energy
5. To familiarize the construction of fuel cell

**Expected Course Outcome:**

1. Examine the properties of the fuels
2. Understand the Conversion of biomass into liquid and gaseous fuels
3. Examine the operation of Hydrogen energy production and storage
4. Understand the Conversion of oil into biodiesel by transesterification process
5. Apply the alternative fuels in SI and CI engines
6. Construct a fuel cell using hydrogen and Producer gas
7. Develop hybrid vehicles running on fuel cell and electrical energy

| Module: 1 | Introduction | 2 hours |
|---|---|---|
| Status of petroleum reserves, economics; Need for alternative fuels; Review of fuel properties. | | |
| **Module: 2** | **Hydrogen** | **6 hours** |
| Properties; Production and storage methods; Safety aspects; Use in SI and CI engines; Performance and emissions. | | |
| **Module: 3** | **Alcohols and ethers** | **8 hours** |
| Natural Gas, LPG, biogas, producer gas, syngas etc.; Properties; Production and storage methods - CNG and LNG, gasification, digesters; Use in SI and CI engines; Performance and emission characteristics; Dual fuel and HCCI modes. | | |
| **Module: 4** | **Air Pollution Measurements** | **8 hours** |
| Methanol and ethanol; DME and DEE; Properties; Production methods; Use in SI and CI engines - blends and emulsions; Performance and emissions. | | |
| **Module: 5** | **Biodiesel** | **8 hours** |
| Composition and properties; Challenges of use in CI engines, solutions - preheating, blending; Transesterification; Performance and emissions; Oils from waste - cooking oil, wood, rubber, plastic etc. | | |
| **Module: 6** | **Solid fuels** | **5 hours** |
| Biomass - processing and usage, forms - municipal solid waste, wood | | |

| | | |
|---|---|---|
| **Module: 7** | **Clean Technology** | **6 hours** |
| Fuel cells - types, working; Hybrid and electric vehicles; Solar power; Challenges; Engine performance. | | |
| **Module: 8** | **Contemporary issues** | **2 hours** |
| | **Total Lecture hours** | **45 hours** |

**Text Book(s)**

1. Thipse S. S, (2010), Alternative Fuels: Concepts, Technologies and Developments, Jaico Publishing House.
2. Richard L. Bechtold, (2014), Alternative Fuels Guidebook, Society of Automotive Engineers (SAE).
3. Ganesan V., (2012), Internal Combustion Engines, McGraw-Hill Education India Pvt. Ltd.

**Reference Books**

1. Michael F. Hordeski, (2013), Alternative Fuels: The Future of Hydrogen, The Fairmont Press, Inc.
2. Larminie J., Lowry J., (2004), Electric Vehicle Technology Explained, Wiley.
3. Daniel J. Holt, (2003), Fuel Cell Powered Vehicles: Automotive Technology of the Future, Society of Automotive Engineers (SAE).

**Mode of evaluation:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

| | | | |
|---|---|---|---|
| **Recommended by Board of Studies** | 04.03.2016 | | |
| **Approved by Academic Council** | No. 40 | **Date** | 18.03.2016 |

| MEE6050 | POWER PLANT ENGINEERING | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 0 | 3 |
| Pre-requisite | Nil | Syllabus version | | | | |
| | | 1.0 | | | | |

**Course Objectives:**

1. To understand the various power generation units and power cycles.
2. To learn about the steam generators, combustion and firing methods in order to make the fullest use of thermal power potentialities of the country.
3. To understand in detail about nuclear, gas turbine, hydro and diesel power plants which play an important role in power generation.

**Expected Course Outcome:**

1. Analyze different power generation types and power generation cycles
2. Know about the types of boilers being used in various industries and their applications
3. Evaluate the performance of power plants
4. Describe various turbines used for power generation and their governing methods
5. Identify different devices used for operating and maintaining power plant equipment

| Module: 1 | Introduction | 5 hours |
|---|---|---|
| Power plants - Features, Components and layouts - Selection of site | | |
| **Module: 2** | **Power plants** | **6 hours** |
| Working principle of steam, hydro, nuclear, gas turbine and diesel power plants | | |
| **Module: 3** | **Heat Cycles** | **8 hours** |
| Introduction. - Analysis of steam cycles - Rankine cycle - Reheating and regenerative cycles Heat cycles of gas turbine engines. Steam and gas turbine components. | | |
| **Module: 4** | **Energy conversion** | **7 hours** |
| Energy conversion in a turbine stage. Geometrical and gas dynamic characteristics of turbine cascades. Turbine cascades and losses in turbine stage efficiency. | | |
| **Module: 5** | **Multi-stage turbines** | **6 hours** |
| Multi-stage turbines, radial turbines, partial admission turbines. Governing of steam and gas turbines. | | |
| **Module: 6** | **Modeling** | **6 hours** |
| Types of simulation. Modeling of typical power plant equipment. Steady state simulation. Dynamic response of thermal systems. | | |
| **Module: 7** | **Control systems** | **5 hours** |
| Automatic control-Pressure, flow and liquid level measurement in power plant-Boiler feed water control-Super heater temperature control-Steam pressure reducing and desuperheating devices. | | |
| **Module: 8** | **Contemporary issues** | **2 hours** |

| | | | |
|---|---|---|---|
| **Total Lecture hours** | | | **45 hours** |
| **Text Book(s)** | | | |
| 1. M. M. El- Wakil, Power Plant Technology (2002), McGraw Hill.<br>2. E. E. Khalil, Power Plant Design, an Abacus Book, (1990), CRC Press. | | | |
| **Reference Books** | | | |
| 1. Raven, Automatic Control Engineering, 5th Edition – Revised (1994) McGraw Hill.<br>2. S. M. Yahya, Turbines, Compressors and Fans, 4th Edition (2004), McGraw Hill | | | |
| **Mode of evaluation:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test | | | |
| **Recommended by Board of Studies** | 04.03.2016 | | |
| **Approved by Academic Council** | No. 40 | **Date** | 18.03.2016 |

| MEE6051 | WIND ENERGY TECHNOLOGY | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 0 | 3 |
| Pre-requisite | Nil | Syllabus version | | | | |
| | | 1.0 | | | | |

**Course Objectives:**

1. To understand the processes of generation of wind, its potential and energy extraction
2. To identify and estimate wind resource potential of an area.
3. To understand the aerodynamic principles of turbine blade design.
4. To understand the functioning of wind electric generators and the operation wind forms.

**Expected Course Outcome:**

At the end of the course, the students will be able to

1. Assess the wind energy resources potential and site selection techniques.
2. Understand the basics of the wind resources, wind energy distribution, and utilization of wind energy.
3. Identify various parameters that influences the performance of devices / processes using aerodynamic techniques.
4. Design a wind mill rotor and evaluate its performance.
5. Study the basics of wind energy conversion systems and its configurations.
6. Examine the site preference for wind farm and analysis of environmental impacts.
7. Understand the applications of wind turbines technologies for some specific energy requirements
8. Evaluate the site requirement for understanding the contemporary issues with respect to wind turbine operations and recent advancements in wind electric generations.

| Module: 1 | Introduction | 4 hours |
|---|---|---|

Historical Perspectives on Wind Turbines, Indian Energy Scenario, Global Energy Scenario, Introduction to Indian Wind Industry, Wind Energy potential of India and Global Wind Installations.

| Module: 2 | Basics of Wind Resource Assessment | 7 hours |
|---|---|---|

Power in the wind, Wind Characteristics, Measurement of wind using anemometers (cup anemometer, propeller anemometer, pressure plate anemometer, pressure tube anemometer, sonic anemometer and other remote wind speed sensing techniques), Turbulence, Wind Power Density. Average wind speed calculation, Statistical models for wind data analysis (Weibull and Rayleigh distribution), Energy estimation of wind regimes, Wind Rose, Wind Monitoring Station Siting and Instrumentation.

| Module: 3 | Aerodynamics | 6 hours |
|---|---|---|

Introduction to Aerofoil design, NACA profiles, Lift and drag principle, Lift and drag co-efficient, Axial Momentum theory, Momentum theory for rotating Wake, Blade element theory, Strip theory, Tip losses

| Module: 4 | Rotor Design and Performance | 7 hours |
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Design of rotor, Wind Machine parameters (swept area, power co-efficient, torque co-efficient, thrust, solidity, tip-speed ratio, angle of attack etc.), Power Curve, Energy Estimation, Capacity Factor

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| **Module: 5** | **Wind Energy Conversion Systems** | **7 hours** |
| Types, Components of Modern Wind Turbine (HAWT and VAWT), Fixed and Variable Speed operations, Power Control (Passive stall, Active pitch, Passive pitch and Active stall), Electrical aspects of wind turbine, Safety of wind turbines | | |
| **Module: 6** | **Wind Farm Design and Health (Condition) Monitoring** | **6 hours** |
| Planning of wind farm, Site selection, Micros ting, Grid Integration, Power evacuation, Wind Farm Feasibility Studies, Preparation of DPR, Environmental Impacts. | | |
| **Module: 7** | **Small Wind Turbines** | **6 hours** |
| Water pumping wind mills, offshore wind energy, Wind turbine testing, future developments. | | |
| **Module: 8** | **Contemporary issues** | **2 hours** |
| | **Total Lecture hours** | **45 hours** |

**Text Book(s)**

1. Wind Energy Fundamentals, Resource Analysis and Economics, Sathyajith Mathew, Springer Publications, ISBN 978-3-540-30906-2, 2006 edition.
2. Wind Energy Explained: Theory, Design and Application 2nd Edition, by James F. Manwell , Jon G. McGowan, Anthony L. Rogers,ISBN-10: 0470015004, Wiley; 2nd edition (2010).
3. Wind Energy: Theory and Practice, Siraj Ahmed, 2nd Edition, PHI Learning, 2011, ISBN8120344901, 9788120344907

**Reference Books**

1. Wind Turbine Technology, A. R. Jha, Ph.D., (2010), by CRC Press, ISBN 9781439815069 – CAT # K10772.
2. Wind Energy Handbook 2nd Edition,((2011), by Tony Burton , Nick Jenkins, David Sharpe , Ervin Bossanyi , ISBN-10: 0470699752, Wiley; 2nd edition.
3. Small Wind Turbines, Analysis, Design, and Application, (2011), David Wood, Springer - Verlag London, ISBN 978-1-84996-174-5.
4. A Guide to Small Wind Energy Conversion Systems, John Twidell, Cambridge University Press, (2011), ISBN 10: 0521281628.
5. Offshore Wind Power, Edited by John Twidell and Gaetano Gaudiosi, 2009 Edition, ISBN 978-0906522-639.
6. Robert Gasch and JochenTwele, (2012), Wind Power Plants. Fundamentals, Design, Construction and Operation.

**Mode of evaluation:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

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| **Recommended by Board of Studies** | 04.03.2016 | | |
| **Approved by Academic Council** | No. 40 | **Date** | 18.03.2016 |

| MEE6053 | ENERGY SYSTEMS MODELING AND ANALYSIS | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 0 | 3 |
| Pre-requisite | Nil | Syllabus version | | | | |
| | | 1.1 | | | | |

**Course Objectives:**

1. To impart knowledge on various energy conversion technologies including conventional Power.
2. To optimize various energy systems.
3. To apply the dynamic, linear and geometric programming for solving problems related to energy systems.

**Expected Course Outcome:**

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

1. Identify the specific parameters for optimization in workable systems
2. Compare different methods of power production and their limitation in energy conversion
3. Evaluate inverse problems to determine optimized values for maximization or minimization problems
4. Develop mathematical models for various energy systems and components
5. Optimize energy systems and their related components
6. Analyze energy systems using dynamic programming techniques for constrained optimization
7. Understand industry requirements and incorporate knowledge on thermodynamic limits of system performance

| Module: 1 | Introduction | 2 hours |
|---|---|---|

Overview of various technologies and conventional methods of energy conversion - Power cycles

| Module: 2 | Energy systems | 7 hours |
|---|---|---|

Designing a workable system - Workable and optimum systems - Steps in arriving at a workable system Creativity in concept selection - Workable Vs optimum system- Equation fitting - Mathematical modeling- Polynomial representation - Functions of two variables - Exponential forms - Best fit method of least squares.

| Module: 3 | Modeling | 6 hours |
|---|---|---|

Modeling of thermal equipment - Counter flow heat exchanger - Evaporators and condensers - Heat exchanger effectiveness - Effectiveness of a counter flow heat exchanger – NTU -Pressure drop and pumping power.

| Module: 4 | Simulation | 6 hours |
|---|---|---|

System simulation - Classes of simulation - Information flow diagrams - Sequential and simultaneous calculations - Successive substitution - Newton-Raphson method.

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| **Module: 5** | **Optimization techniques** | **7 hours** |
| Optimization - Mathematical representation of optimization problems - Optimization procedure - Setting up the mathematical statement of the optimization problem - Lagrange multipliers - Lagrange multiplier equations - Unconstrained optimization - Constrained optimization - Sensitivity coefficients - Search methods - Single variable - Exhaustive-Dichotomous and Fibonacci - Multivariable unconstrained - Lattice-univariable and steepest ascent | | |
| **Module: 6** | **Analysis** | **7 hours** |
| Dynamic programming - Characteristic of the dynamic programming solution -Apparently constrained problem - Application of dynamic programming to energy system problems - Geometric programming One independent variable unconstrained - Multivariable optimization - Constrained optimization with zero degree of difficulty - Linear programming - Simplex method - Big-M method - Application of LP to thermal systems | | |
| **Module: 7** | **Thermodynamic properties** | **7 hours** |
| Thermodynamic properties - Internal energy and enthalpy - Pressure temperature relationship at saturated conditions - Specific heat - P-V-T equations - Mathematical modeling - Need for mathematical modeling - Criteria for fidelity of representation - Linear regression analysis | | |
| **Module: 8** | **Contemporary issues** | **2 hours** |
| **Total Lecture hours** | | **45 hours** |

**Text Book(s)**

1. Nagrath I. J. and M. Gopal, Systems Modeling and Analysis (1982), Tata McGraw-Hill.
2. Y. Jaluria, Design and Optimization of Thermal Systems (2007), 2nd Edition, McGraw-Hill.

**Reference Books**

1. B.K. Hodge and Robert P. Taylor, Analysis and Design of Thermal Systems (1999), 3rd Edition, Prentice-Hall Inc.

**Mode of evaluation:** Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

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| **Recommended by Board of Studies** | 27.09.2017 | | |
| **Approved by Academic Council** | No. 47 | **Date** | 05.10.2017 |

| MEE6054 | ENERGY IN BUILT ENVIRONMENT | L | T | P | J | C |
|---|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 0 | 3 |
| Pre-requisite | Nil | Syllabus version | | | | |
| | | 1.1 | | | | |

**Course Objectives:**

1. To enable essential and practical understanding of the basic energy requirements in buildings for different applications
2. To understand the external and internal energy processes which control the built environment
3. To study emerging technologies in building energy management

**Expected Course Outcome:**

After taking this course the student will be able to

1. Understand the various energy use and energy processes involved for building comfort
2. Infer the knowledge on using proper passive techniques to achieve amicable light energy in building
3. Understand the interaction of various external parameters influencing the thermal performance in building envelopes through the walls
4. Choose proper methodology for energy audit in order to conserve energy in buildings
5. Select the energy requirements for lighting, air-conditioning, etc.
6. Select the energy conservation measures for proper ventilation in buildings
7. Understand the management of indoor environmental requirements

| Module: 1 | Introduction | 6 hours |
|---|---|---|

Indoor activities and environmental control - Internal and external factors on energy use - Characteristics of energy use and its management -Macro aspect of energy use in dwellings and its implications - Thermal comfort - Ventilation and air quality - Air-conditioning requirement - Visual perception - Illumination requirement - Auditory requirement

| Module: 2 | Solar energy and day-lighting | 7 hours |
|---|---|---|

The sun-earth relationship - Climate, wind, solar radiation and temperature - Sun shading and solar radiation on surfaces - Energy impact on the shape and orientation of buildings – Lighting and daylighting: Characteristics and estimation, methods of day-lighting - Architectural considerations for day-lighting

| Module: 3 | Heat transfer | 6 hours |
|---|---|---|

Steady and unsteady heat transfer through wall and glazed window

| Module: 4 | Thermal performance | 6 hours |
|---|---|---|

Standards for thermal performance of building envelope - Evaluation of the overall thermal transfer.

| Module: 5 | Energy requirements in buildings | 5 hours |
|---|---|---|

Thermal gain and net heat gain - End-use energy requirements - Status of energy use in buildings - Estimation of energy use in a building

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|---|---|---|
| **Module: 6** | **Energy Audit** | **7 hours** |
| Energy audit and energy targeting - Technological options for energy management - Natural and forced ventilation – Indoor environment and air quality - Airflow and air pressure on buildings - Flow due to stack effect | | |
| **Module: 7** | **Ventilation** | **6 hours** |
| Passive building architecture – Radiative cooling - Solar cooling techniques - Solar desiccant dehumidification for ventilation - Natural and active cooling with adaptive comfort – Evaporative cooling – Zero energy building concept | | |
| **Module: 8** | **Contemporary issues** | **2 hours** |
| **Total Lecture hours** | | **45 hours** |

**Text Book(s)**

1. Intelligent Buildings: Design, Management and Operations (2010) by Derek Clements-Croome. Thomas Telford, U. K.
2. Green Building: Principles and Practices in Residential Construction (Go Green with Renewable Energy Resources) by Abe Kruger (Author), Carl Seville (Author), Jim Devoe (Editor) Hardcover – Import, 21 Apr A. Shaw (1991), Energy Design for Architects, AEE Energy Books

**Reference Books**

1. Heating and Cooling of Buildings: Design for Efficiency, Revised Second Edition (2009) CRC Press USA.

**Mode of assessment**: Continuous Assessment Test, Quizzes, Assignments, Final Assessment Test

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|---|---|---|---|
| **Recommended by Board of Studies** | 27.09.2017 | | |
| **Approved by Academic Council** | No. 47 | **Date** | 05.10.2017 |