**HONORS DEGREE IN A DISCIPLINE**

Honors degree in a discipline:

The objective of Honors degree in a discipline is to provide additional learning opportunities for academically motivated students and it is an optional feature of the B. Tech. programme.

1. A student shall be permitted to register for Honors program at the beginning of 4th semester provided that the student must have acquired a minimum of 8.0 CGPA up to the end of 3rd semester without any backlogs. In case a student fails to meet the CGPA requirement of 8.0 CGPA for Degree with Honors at any point after registration, he / she will be dropped from the list of students eligible for Degree with Honors and they will receive regular B.Tech degree only. However, such students will receive a separate grade sheet mentioning the additional courses completed by them. The concerned BoS shall decide on the minimum enrolments for offering Honors program by the department.
2. In order to earn a Honors degree in his/her discipline, a student has to earn 20 extra credits by studying advanced theory and laboratory courses additionally in the concerned branch of Engineering. However, a student shall be permitted to choose only those courses that he/she has not studied in any form during the Programme. The concerned BoS shall also consider courses listed under professional electives of the respective B. Tech programs for the requirements of B. Tech (Honors).
3. In place of advanced courses, he/she can study equivalent MOOC courses available under SWAYAM or other platforms with a minimum duration of 8 weeks as decided by the Institute from time to time. The evaluation pattern will be similar to the regular programme evaluation.
4. Attendance will not be monitored for MOOC courses. Students have to acquire a certificate from the agencies approved by the BOS with grading or marks or pass / fail in order to earn credits. If the MOOC course is a pass / fail course without any grades, the grade to be assigned will be as decided by the BoS.
5. Honors degree must be completed simultaneously with a major degree program. A student cannot earn Honors degree after he / she has already earned bachelor’s degree.

**N.B.K.R. INSTITUTE OF SCIENCE &TECHNOLOGY:: VIDYANAGAR**

*(AUTONOMOUS)*

**CIVIL ENGINEERING**

**SCHEME OF INSTRUCTION AND EVALUATION**

(With effect from the batch admitted in the academic year 2019-2020)

**III YEAR OF FOUR YEAR B.TECH. HONORS DEGREE COURSE – II SEMESTER**

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| **S.NO.** | **Course**  **Code** | **Course Title** | **Contact Hours/**  **Week** | | | **Credits** | **Evaluation** | | | | | | | | | |
| **Sessional**  **Test-I** | | | **Sessional**  **Test-II** | | | **Total Sessional Marks (Max. 40)** | **Semester**  **End Examination** | | **Max.**  **Total Marks** |
| **THEORY** | **L** | **T** | **P** | **Test-I**  **(2 hrs.)** | **Assignment-I** | **Max.**  **Marks** | **Test-II**  **(2 hrs.)** | **Assignment-II** | **Max**  **Marks** | **Duration**  **In Hours** | **Max**  **Marks** |
| 1 | 19HDCE01 | Analysis and Design of Advanced RC Members | 3 | 0 | 0 | 3 | 34 | 6 | 40 | 34 | 6 | 40 | 0.8(Better of two sessional tests)  +2(Other) | 3 | 60 | 100 |
| 2 | 19HDCE02 | Geosynthetics & Reinforced Soil Structures | 3 | 0 | 0 | 3 | 34 | 6 | 40 | 34 | 6 | 40 | 3 | 60 | 100 |
|  |  | **Total** | | | | **6** |  |  |  |  |  |  |  |  |  |  |

**Note:** Mini project (5 credits) can be started only after 3-2 (i.e., after completing two advanced courses) and completed by 4-2 (8th semester).

**19HDCE01 – ANALYSIS AND DESIGN OF ADVANCED REINFORCED CONCRETE MEMBERS**

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| **Course Category** | Professional core | **Credits** | 3 |
| **Course Type** | Theory | **Lecture-Tutorial-Practical** | 3-0-0 |
| **Prerequisite** | Strength of Materials and Design of Reinforced Concrete Structures | **Sessional Evaluation** | 40 |
| **External Evaluation** | 60 |
| **Total Marks** | 100 |

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| **Course**  **Objectives** | 1. To analyze and design of corbels. 2. To understand the behaviour and design of deep beams. 3. To design reinforced concrete flat slabs using direct design and equivalent frame methods. 4. To impart knowledge for analysis of reinforced concrete buildings subjected to seismic forces. 5. To carry out the design of rectangular shear wall. 6. To analyze reinforced concrete buildings for wind loads. | |
| **Course Outcomes** | CO1 | Perform analysis and design of corbels. |
| CO2 | Analyze and design of deep beams. |
| CO3 | Analyze and design reinforced concrete flat slabs using IS code recommendations. |
| CO4 | Analyze reinforced concrete buildings for seismic forces and carryout ductility considerations in the design using IS 13920. |
| CO5 | Analyze and design simple rectangular shear wall. |
| CO6 | Analyze reinforced concrete buildings for wind loads using IS code recommendations |
| **Course**  **Content** | **UNIT –I**  **DESIGN OF CORBELS:** Introduction - Initial dimensioning – Analysis of forces in corbels - Design of corbels.  **UNIT – II**  **DESIGN OF DEEP BEAMS:** Introduction - Behaviour of deep beams – Flexural and shear stresses - Design of deep beams.  **UNIT – III**  **DESIGN OF FLAT SLABS:** Introduction – Components of flat slab – IS code recommendations – Direct design method – Equivalent frame method – Shear in flat slab – Openings in flat slab – Slab reinforcement – Design of flat slab.  **UNIT – IV**  **SEISMIC ANALYSIS OF REINFORCED CONCRETE BUILDINGS:** Introduction - Different methods of computing seismic forces on buildings - Ductility considerations in earthquake resistant design of reinforced concrete buildings based on IS 13920.  **UNIT – V**  **DESIGN OF SHEAR WALLS:** Introduction – Classification of shear walls - Loads in shear walls - Design of simple rectangular shear walls.  **UNIT – VI**  **WIND LOAD ANALYSIS OF REINFORCED CONCRETE BUILDINGS:** Introduction – IS code recommendations - Analysis of wind loads using pressure coefficient method. | |
| **Textbooks**  **& Reference books** | **TEXTBOOKS:**   1. N. Krishna Raju, *Advanced reinforced Concrete Design,* New Age International (P) Ltd. CBS Publishers and distributors, 3rd edition, 2016. 2. P. C. Varghese, *Advanced Reinforced Concrete Design*, Prentice Hall of India Pvt. Ltd, 2nd edition, 2009. 3. Pankaj Agarwal & Manish Shrikhande, *Earthquake Resistant Design of Structures*, Prentice Hall of India Pvt. Ltd, 2011.   **REFERENCES:**   * 1. S. R. Karve& V. L. Shah, *Limit State Theory and Design of Reinforced Concrete*, Structures Publications, 8thedition, 2014.   2. Plain and Reinforced Concrete – Code of practice (IS: 456-2000).   3. SP-64: Explanatory handbook on Indian standard code of practice for design loads (other than earthquake) for buildings and structures (SP 64 (S&T): 2001. | |

**CO-PO Mapping:** 3-High Mapping, 2-Moderate Mapping, 1-Low Mapping, - -Not Mapping

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** |
| **CO1** | 3 | - | 1 | - | 2 | - | - | 1 | - | - | - | - |
| **CO2** | 3 | - | 2 | - | 2 | - | - | 1 | - | - | 2 | - |
| **CO3** | 3 | - | 1 | - | 2 | - | - | 1 | - | - | 2 | - |
| **CO4** | 3 | - | 1 | - | - | 1 | 1 | 1 | - | - | - | - |
| **CO5** | 2 | - | 1 | - | 2 | - | - | 1 | - | - | 2 | - |
| **CO6** | 2 | - | - | - | - | 1 | 1 | - | - | - | - | - |

**19HDCE02 – GEOSYNTHETICS AND REINFORCED SOIL STRUCTURES**

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| **Course Category** | Professional Core | **Credits** | 3 |
| **Course Type** | Theory | **Lecture - Tutorial - Practical** | 3 - 0 - 0 |
| **Prerequisite** | Geotechnical Engineering- I | **Sessional Evaluation** | 40 |
| **Semester End Exam Evaluation** | 60 |
| **Total Marks** | 100 |

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| **Course Objectives** | 1. To explain various types of geosynthetics and their manufacturing methods. 2. To study physical, mechanical and hydraulic properties of geosynthetics. 3. To analyze slope stability of reinforced soil slopes using different methods. 4. To understand the applications of geosynthetics in foundations and selection of geotextiles based on flow characters of soils. 5. To discuss the use of geosynthetics in the construction of pavements. 6. To study the use of geosynthetics in the construction of landfills. | |
| **Course**  **Outcomes** | CO1 | Understand various types of geosynthetics. |
| CO2 | Assess the physical, mechanical and hydraulic properties of geosynthetics. |
| CO3 | Analyze the slope stability of reinforced soil. |
| CO4 | Compute drainage and filter applications of geosynthetics. |
| CO5 | Demonstrate the use of geosynthetics in the construction of pavements. |
| CO6 | Application of the geosynthetics in the construction of landfills. |
| **Course**  **Content** | **UNIT – I**  **INTRODUCTION:** Historical background of reinforced soil – Principles of reinforced soil through Mohr’s circle analysis – Factors affecting behaviour and performance -Types of geosynthetics like geotextiles, geogrids, geonets, geocells, geo-composites and their manufacturing methods.  **UNIT – II**  **TESTING METHODS FOR GEOSYNTHETICS:** Need for testing **–** Collection of test sample – Identification of test sample - Geotextile properties: physical, mechanical and hydraulic properties - Apparent opening size – In-plane and cross-plane permeability tests – Gradient ratio test and long term flow test.  **UNIT – III**  **GEOSYNTHETICS FOR STEEP SLOPES:** Introduction - Different types of arrangements of reinforcements – Applications of reinforced soil – Failure modes of reinforced soil slope - Limit equilibrium design methods for circular arc slope analysis - General guidelines for the design of reinforced soil slopes - Jewell’s method for slope stability analysis.  **UNIT – IV**  **DRAINAGE AND FILTRATION APPLICATIONS OF GEOSYNTHETICS:** Introduction – Functions of a filter – Filtration behaviour – Applications – Drainage, erosion control– Filtration flow conditions – Granular filter design criteria – Geotextile filter requirements.  **UNIT – V**  **PAVEMENT APPLICATIONS:** Introduction – Mechanisms and concepts of pavement - applications – Type of Geosynthetics used in pavement - role of subgrade conditions **-** Geosynthetics for separation and reinforcement in flexible pavements – Design principles of unpaved roads by Giroud-Noiray approach – Use of geosynthetics for construction of heavy container yards and railway lines.  **UNIT – VI**  **CONSTRUCTION OF LANDFILLS USING GEOSYNTHETICS:** Introduction – Types of landfills – Criteria for landfills – Landfill components – Landfill liners and covers - Guidelines - Role of geosynthetics - Use of geomembranes and Geosynthetics Clay Liner (GCL) as barriers. | |
| **Textbooks**  **and References** | **TEXTBOOKS:**   1. G L Sivakumar Babu, *An Introduction to Soil Reinforcement and Geosynthetics,* Universities press, 2013. 2. G.V. Rao, PK Banerjee, J.T. Shahu, G.V. Ramana, *Geosynthetics - New Horizons* Asian Books Private Ltd., 2004. 3. B.C. Punmia, A. K. Jain & A.K Jain, *Soil Mechanics and Foundation Engineering,* Laksmi publications, 17th edition, 2017.   **REFERENCES:**   1. Koerner, R.M, *Designing with Geosynthetics,* Prentice Hall, 6th edition, Xlibris Publishers, 2012. 2. Jewell, R.A, *Soil Reinforcement with Geotextiles*, Special Publication No. 123, CIRIA, Thomas Telford. London, UK, 1996. | |

**CO-PO Mapping:** 3-High Mapping, 2-Moderate Mapping, 1-Low Mapping, - -Not Mapping

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** |
| **CO1** | 1 | - | - | 2 | 1 | 2 | - | - | - | - | - | - |
| **CO2** | 2 | 2 | - | 1 | 1 | 2 | - | - | - | - | - | - |
| **CO3** | 2 | - | 1 | 2 | 1 | 1 | - | - | - | - | - | - |
| **CO4** | 2 | - | - | 2 | 2 | 1 | - | - | - | - | - | - |
| **CO5** | 2 | - | - | 2 | 1 | - | - | - | - | - | - | - |
| **CO6** | 2 | - | - | 2 | 1 | 1 | - | - | - | - | - | - |

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**CIVIL ENGINEERING**

**SCHEME OF INSTRUCTION AND EVALUATION**

(With effect from the batch admitted in the academic year 2019-2020)

**IV YEAR OF FOUR YEAR B.TECH. HONORS DEGREE COURSE – I SEMESTER**

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| **S.NO.** | **Course**  **Code** | **Course Title** | **Contact Hours/**  **Week** | | | **Credits** | **Evaluation** | | | | | | | | | |
| **Sessional**  **Test-I** | | | **Sessional**  **Test-II** | | | **Total Sessional Marks (Max. 40)** | **Semester**  **End Examination** | | **Max.**  **Total Marks** |
| **THEORY** | **L** | **T** | **P** | **Test-I**  **(2 hrs.)** | **Assignment-I** | **Max.**  **Marks** | **Test-II**  **(2 hrs.)** | **Assignment-II** | **Max**  **Marks** | **Duration**  **In Hours** | **Max**  **Marks** |
| 1 | 19HDCE03 | Advanced FEA | 3 | 0 | 0 | 3 | 34 | 6 | 40 | 34 | 6 | 40 | 0.8(Better of two sessional tests)  +  0.2(Other) | 3 | 60 | 100 |
| **TOTAL** | | | | | | **3** |  | | | | | | | | | |

**19HDCE03 – ADVANCED FINITE ELEMENT ANALYSIS**

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| **Course Category** | Professional Core | **Credits** | 3 |
| **Course Type** | Theory | **Lecture-Tutorial-Practical** | 3-0-0 |
| **Prerequisite** | Finite Element Method | **Sessional Evaluation** | 40 |
| **External Evaluation** | 60 |
| **Total Marks** | 100 |

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| **Course**  **Objectives** | 1. To understand the basic principles and approaches of finite element method. 2. To analyze the one dimensional spring and bar elements. 3. To assess the suitability of finite element method in the analysis of trusses. 4. To apply the finite element approach for beam elements under bending. 5. To make use of usefulness of finite element method in analyzing structural frames. 6. To understand the concepts of shape functions, interpolation and convergence criteria. | |
| **Course Outcomes** | CO1 | Appreciate the principles and various approaches of finite element method. |
| CO2 | Develop the differential equation and analyze one dimensional spring and bar elements. |
| CO3 | Derive the differential equation and analyze two-dimensional and three-dimensional trusses using finite element method. |
| CO4 | Make use of finite element method in deriving differential equation and analyze the beam elements for various types of loads. |
| CO5 | Examine the suitability of finite element method in the analysis of structural frame elements. |
| CO6 | Develop shape functions using Lagrangian interpolation and understand the convergence criteria for various elements. |
| **Course**  **Content** | **UNIT –I**  **BASICS OF FINITE ELEMENT METHOD:** Introduction - Steps involved in finite element method (FEM) - Different approaches of FEM: Direct method, Variational Principle and Weighted Residual method, variational method, Modified Galerkin method - Advantages and disadvantages of finite element method-Limitations of Finite element method.  **UNIT – II**  **ANALYSIS OF ONE-DIMENSIONAL ELEMENTS:** Differential equation for one-dimensional element - Axial deformation of bars - Axial spring element.  **UNIT – III**  **ANALYSIS OF TRUSSES:** Two-dimensional plane truss elements – Three-dimensional space truss elements - Stresses due to lack of fit and temperature changes.  **UNIT – IV**  **BEAM BENDING:** Governing differential equation for beam bending - Two node beam element - Exact solution for uniform beams subjected to distributed loads using superposition - Calculation of stresses in beams - Thermal stresses in beams.  **UNIT – V**  **ANALYSIS OF STRUCTURAL FRAMES:** Plane frame element - Thermal stresses in frames - Three-dimensional space frame element  **UNIT – VI**  **ANALYSIS OF SECOND ORDER PROBLEMS:** Lagrangian interpolation – Shape functions - Pascal’s triangle - Convergence criteria. | |
| **Textbooks**  **& Reference books** | **TEXT BOOKS:**   1. J. N. Reddy, *An Introduction to the Finite Element Method*, McGraw-Hill Education, 3rd Edition, 2005. 2. C. S. Krishnamoorty, *Finite Element Analysis : Theory and programming*, Tata McGraw-Hill publishing company ltd. 2nd edition, 2007. 3. S. S. Bhavikatti, Finite Element Analysis, New age international publishers, 3rd edition, 2015.   **REFERENCE BOOKS:**   * + 1. O. C. Zienkiewicz, R. L. Talor and J. Z. Zhu, *The Finite Element Method : Its bacis and Fundamentals*, Butterworth-Heinemann publishers, 7th edition, 2013.     2. Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt, *Concepts and Applications of Finite Element Analysis*, Wiley publishers, 4th edition, 2001.     3. Daryl L. Logan, A First Course in the Finite Element Method, CL Engineering, 5th edition, 2010. | |

**CO-PO Mapping:** 3-High Mapping, 2-Moderate Mapping, 1-Low Mapping, - -Not Mapping

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** |
| **CO1** | 2 | - | - | - | 2 | - | - | - | - | - | 1 | 1 |
| **CO2** | 3 | - | 1 | - | 2 | - | - | - | - | - | 1 | 1 |
| **CO3** | 3 | - | 1 | - | 2 | - | - | - | - | - | 1 | 1 |
| **CO4** | 3 | - | 1 | - | 2 | - | - | - | - | - | 1 | 1 |
| **CO5** | 3 | - | 1 | - | 2 | - | - | - | - | - | 1 | 1 |
| **CO6** | 2 | - | - | - | 1 | - | - | - | - | - | 1 | 1 |

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(With effect from the batch admitted in the academic year 2019-2020)

**IV YEAR OF FOUR YEAR B.TECH. HONORS DEGREE COURSE – II SEMESTER**

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| **S.NO.** | **Course**  **Code** | **Course Title** | **Contact Hours/**  **Week** | | | **Credits** | **Evaluation** | | | | | | | | | |
| **Sessional**  **Test-I** | | | **Sessional**  **Test-II** | | | **Total Sessional Marks (Max. 40)** | **Semester**  **End Examination** | | **Max.**  **Total Marks** |
| **THEORY** | **L** | **T** | **P** | **Test-I**  **(2 hrs.)** | **Assignment-I** | **Max.**  **Marks** | **Test-II**  **(2 hrs.)** | **Assignment-II** | **Max**  **Marks** | **Duration**  **In Hours** | **Max**  **Marks** |
| 1. | 19HDCE04 | Intelligent Transport Systems | 3 | 0 | 0 | 3 | 34 | 6 | 40 | 34 | 6 | 40 | 0.8(Better of two sessional tests)  +  0.2(Other) | 3 | 60 | 100 |
| 2. | 19HDCE05 | Advanced Wastewater treatment | 3 | 0 | 0 | 3 | 34 | 6 | 40 | 34 | 6 | 40 | 3 | 60 | 100 |
| **TOTAL** | | | | | | **6** |  | | | | | | | | | |

**19HDCE04 -INTELLIGENT TRANSPORT SYSTEMS**

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| **Course Category** | Professional Core | **Credits** | 3 |
| **Course Type** | Theory | **Lecture - Tutorial - Practical** | 3 - 0 - 0 |
| **Prerequisite** | Transportation Engineering | **Sessional Evaluation** | 40 |
| **Semester End Exam Evaluation** | 60 |
| **Total Marks** | 100 |

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| **Course Objectives** | 1. To discuss various data collection techniques in Intelligent Transport Systems (ITS). 2. To explain telecommunication processes in ITS. 3. To understand various functional areas in ITS. 4. To demonstrate various user services and needs in ITS. 5. To analyze automated highway systems in traffic control and safety. 6. To discuss importance of planning in mass transit systems. | |
| **Course Outcomes** | CO1 | Know various data collection techniques in ITS. |
| CO2 | Understand the importance of communication and information management for traffic management. |
| CO3 | Assess use and application of various functional systems in ITS. |
| CO4 | Assess various user services to operate vehicles using ITS. |
| CO5 | Evaluate and assess ITS programmes and their implementation in developed and developing countries. |
| CO6 | Identify and assess appropriate mass transit system. |
| **Course**  **Content** | **UNIT - I**  **INTRODUCTION:** Intelligent Transport Systems: Definition– Identification – Objectives - Historical Background - Benefits - ITS Data collection techniques – Detectors - Automatic Vehicle Location (AVL) - Automatic Vehicle Identification (AVI) - Geographic Information Systems (GIS) - Video data collection.  **UNIT - II**  **TELECOMMUNICATIONS IN ITS:** Importance of telecommunications in the ITS– Information Management – Traffic Management Centers (TMC) – Vehicle-Road side communication – Vehicle Positioning System  **UNIT - III**  **ITS FUNCTIONAL AREAS:** Advanced Traffic Management Systems (ATMS), Advanced Traveler Information Systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Vehicle Control Systems (AVCS), Advanced Public Transportation Systems (APTS), Advanced Rural Transportation Systems (ARTS).  **UNIT - IV**  **ITS USER NEEDS AND SERVICES:** Travel and Traffic management, Public Transportation Management, Electronic Payment, Commercial Vehicle Operations, Emergency Management, Advanced Vehicle safety systems, Information Management.  **UNIT – V**  **AUTOMATED HIGHWAY SYSTEMS:** Vehicles in Platoons – Integration of Automated Highway Systems. ITS Programmes in the World – Overview of ITS implementations in developed countries, ITS in developing countries.  **UNIT VI**  **MASS TRANSIT SYSTEMS:** Need for public transportation, history of mass transit in India - current problems and statistics, Mass Transit Systems Bus and rail transit; characteristics, capacities, route planning. Corridor Identification Prediction issues and forecasting of the travel demand and future desires; corridor identification and corridor screen line analysis. | |
| **Textbooks and Reference Books** | **TEXTBOOKS:**   1. MashrurA.Chowdhury, Adel WadidSadek*“Fundamentals of intelligent transportation systems”* planning 2. Lawrence A. Klein ” *Sensor technologies and Data requirements of ITS”*   **REFERENCE BOOKS:**   1. Kan Paul Chen, John Miles *“ITS Hand Book: Recommendations for World Road Association (PIARC)”*, 2000. 2. Sussman, J. M, *“Perspective on ITS*”, Artech House Publishers, 2005. 3. National ITS Architecture Documentation, US Department of Transportation, 2007 (CD-ROM). | |

**CO-PO Mapping:** 3-High Mapping, 2-Moderate Mapping, 1-Low Mapping, - -Not Mapping

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** |
| **CO1** | - | - | - | - | 1 | 2 | - | - | - | - | 1 | - |
| **CO2** | - | - | - | - | - | 2 | - | - | - | - | 1 | - |
| **CO3** | 1 | 2 | - | - | 1 | - | - | - | - | - | 1 | 1 |
| **CO4** | 1 | 2 | - | 1 | 1 | - | - | - | - | - | 1 | 1 |
| **CO5** | 1 | 2 | - | - | 1 | - | - | - | - | - | 1 | 1 |
| **CO6** | - | - | 1 | 1 | 2 | 1 | - | - | - | - | 1 | 1 |

**19HDCE05 – ADVANCED WASTEWATER TREATMENT**

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| **Course Category** | Program Core | **Credits** | 3 |
| **Course Type** | Theory | **Lecture - Tutorial - Practical** | 3 - 0 - 0 |
| **Prerequisite** | None | **Sessional Evaluation** | 40 |
| **Semester End Exam Evaluation** | 60 |
| **Total Marks** | 100 |

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| **Course Objectives** | 1. To identify various advanced treatment technologies for removal of residual constituents in treated wastewater. 2. To apply filtration, adsorption and gas stripping processes for wastewater treatment. 3. To demonstrate various oxidizing agents and electro chemical processes in wastewater treatment. 4. To explain the kinetics of biological growth in aerobic and anaerobic treatment and to select processes for organics removal. 5. To design various aerobic treatment units and to understand operation & maintenance difficulties in nutrient removal. 6. To illustrate and design various reactors in anaerobic treatment process. | |
| **Course Outcomes** | CO1 | Outline various advanced treatment technologies for the removal of residual constituents in treated wastewater. |
| CO2 | Make use of filtration, adsorption and gas stripping processes for wastewater treatment. |
| CO3 | Apply various oxidizing agents and electro chemical processes in wastewater treatment. |
| CO4 | Develop conceptual schematics required for biological treatment of wastewater. |
| CO5 | Design various reactors in aerobic treatment process and to explain nutrient removal systems. |
| CO6 | Design various reactors in anaerobic treatment process. |
| **Course**  **Content** | **UNIT – I**  **INTRODUCTION:** Need for advanced wastewater treatment – Technologies used for Advanced Treatment – Residual constituents in treated wastewater – Classification of technologies for the removal of organic, inorganic suspended and dissolved solids and biological constituents – Process selection factors.  **UNIT –II**  **ADVANCED WASTEWATER TREATMENT SYSTEMS: Filtration** – Depth filtration, Surface filtration and Membrane filtration processes – Adsorption – Introduction – Fundamentals of adsorption – Type of adsorbents – Development of adsorption isotherms – Freundlich, Langmuir, BET – Activated carbon adsorption, Granular carbon adsorption – Gas stripping – analysis and applications  **UNIT – III**  **ADVANCED OXIDATION PROCESSES:** Theory of advanced oxidation – Types of oxidizing agents – Ozone based and non-ozone based processes – Fenton and photo-Fenton Oxidation  **ELECTROCHEMICAL WASTEWATER TREATMENT PROCESSES:** Introduction – Electro-coagulation – Electrode materials – Electro oxidation process – factors affecting the processes  **UNIT – IV**  **BIOLOGICAL TREATMENT PROCESSES:** Aerobic and anaerobic treatment - kinetics of biological growth - factors affecting growth – attached, suspended and Hybrid growth systems – Determination of kinetic coefficients for organics removal – Biodegradability assessment – selection of process – reactors – batch & continuous type  **UNIT – V**  **AEROBIC TREATMENT OF WASTEWATER:** Design, constructional and relevant parameters of the units – Membrane Biological Reactors – Bio Tower – fluidized bed reactors – Sequential Batch Reactors (SBR) – Nutrient removal systems – Operation & Maintenance (O & M) difficulties – Recent trends  **UNIT – VI**  **ANAEROBIC TREATMENT OF WASTEWATER:** The rationale for anaerobic treatment – General design considerations – Anaerobic sludge blanket processes – design considerations for UASB process – Anaerobic baffled reactor – Anaerobic migrating blanket reactor | |

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| **Textbooks**  **and**  **References** | **TEXTBOOKS:**   1. Metcalf & Eddy, *Waste water Engineering Treatment and Reuse*, McGraw Hill education, 4th edition, 2017. 2. H.S. Peavy, Donald Rowe, George Tchobanoglous, *Environmental Engineering*, McGraw Hill Education,1st edition, July 2017. 3. Mark J. Hammer and Hammer, *water & Waste Water technology,* Prentice Hall India Learning Private Limited, 7th edition, 2012.   **REFERENCE BOOKS:**   1. Arceivala, S.J., *Wastewater treatment for pollution control*, TMH, New Delhi, 3rd edition, 2007. 2. Qasim, S.R, *Wastewater Treatment Plant, Planning, Design & Operation*, Technomic Publications New York, 2004. 3. Lee, C.C. and Shun dar Lin, *Handbook of Environmental Engineering Calculations*, Mc Graw Hill, New York, 2nd 2009. |

**CO-PO Mapping:** 3-High Mapping, 2-Moderate Mapping, 1-Low Mapping, - - Not Mapping

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|  | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** | **PO11** | **PO12** |
| **CO1** | 1 | - | - | 1 | 1 | 3 | 1 | 1 | - | - | - | 1 |
| **CO2** | 3 | 1 | 1 | 1 | 3 | 1 | - | - | 1 | - | 1 | 2 |
| **CO3** | 2 | 1 | 1 | 1 | 3 | 1 | - | - | 1 | - | 1 | 2 |
| **CO4** | 1 | 1 | - | 1 | - | - | - | - | 2 | - | - | 2 |
| **CO5** | 2 | 2 | 1 | 2 | 3 | 1 | 1 | - | 2 | - | 2 | 2 |
| **CO6** | 2 | 2 | 1 | 2 | 3 | 1 | 1 | - | 2 | - | 2 | 2 |