University of Mumbai

Syllabus for

Honours/Minor Degree Program

In

Artificial Intelligence and Machine Learning

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Artificial Intelligence and Machine Learning (AI&ML) (With effect from 2022-23)										
Year & Sem	Course Code & Course Title	Teaching Scheme Hrs / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar / Tutorial	Practical	Internal Assessment	End Sem Exam	Term Work	Oral	Total	Credits
TE Sem V	HAIMLC501: Mathematics for AI & ML	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**	**-**	**-**		**100**	**04**
										Total Credits = 04
TE Sem VI	HAIMLC601: Game Theory using AI & ML	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**	**-**	**-**		**100**	**04**
										Total Credits = 04
BE Sem VII	HAIMLC701: AI&ML in Healthcare	04	--	--	20	80	--	--	100	04
	HAIMLSBL701: AI&ML in Healthcare: Lab	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
										Total Credits = 06
BE Sem VIII	HAIMLC801: Text, Web and Social Media Analytics	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
										Total Credits = 04
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04 = 18										

Artificial Intelligence and Machine Learning: Sem V								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HAIMLC501	**Mathematics for AI&ML**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Practical and Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HAIMLC501	**Mathematics for AI&ML**	**20**	**20**	**20**	**80**	**03**	**--**	**--**	**100**

Course Prerequisites:	
Applied Mathematics, Discrete mathematics	
Course Objectives:	
1	To build an intuitive understanding of Mathematics and relating it to Artificial Intelligence, Machine Learning and Data Science.
2	To provide a strong foundation for probabilistic and statistical analysis mostly used in varied applications in Engineering.
3	To focus on exploring the data with the help of graphical representation and drawing conclusions.
4	To explore optimization and dimensionality reduction techniques.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Use linear algebra concepts to model, solve, and analyze real-world problems.
2	Apply probability distributions and sampling distributions to various business problems.
3	Select an appropriate graph representation for the given data.
4	Apply exploratory data analysis to some real data sets and provide interpretations via relevant visualization
5	Analyze various optimization techniques.
6	Describe Dimension Reduction Algorithms

Module No.		**Topics**	**Hrs.**
1.0		**Linear Algebra**	**05**
	1.1	Vectors and Matrices, Solving Linear equations, The four Fundamental Subspaces, Eigenvalues and Eigen Vectors, The Singular Value Decomposition (SVD).	
2.0		**Probability and Statistics**	**09**
	2.1	Introduction, Random Variables and their probability Distribution, Random Sampling, Sample Characteristics and their Distributions, Chi-Square, t-, and F-Distributions: Exact Sampling Distributions, Sampling from a Bivariate Normal Distribution, The Central Limit Theorem.	
3.0		**Introduction to Graphs**	**10**

	3.1	Quantitative vs. Qualitative data, Types of Quantitative data: Continuous data, Discrete data, Types of Qualitative data: Categorical data, Binary data, Ordinary data, Plotting data using Bar graph, Pie chart, Histogram, Stem and Leaf plot, Dot plot, Scatter plot, Time-series graph, Exponential graph, Logarithmic graph, Trigonometric graph, Frequency distribution graph.	
4.0		**Exploratory Data Analysis**	**09**
	4.1	Need of exploratory data analysis, cleaning and preparing data, Feature engineering, Missing values, understand dataset through various plots and graphs, draw conclusions, deciding appropriate machine learning models.	
5.0		**Optimization Techniques**	**10**
	5.1	Types of optimization-Constrained and Unconstrained optimization, Methods of Optimization-Numerical Optimization, Bracketing Methods-Bisection Method, False Position Method, Newton's Method, Steepest Descent Method, Penalty Function Method.	
6.0		**Dimension Reduction Algorithms**	**05**
	6.1	Introduction to Dimension Reduction Algorithms, Linear Dimensionality Reduction: Principal component analysis, Factor Analysis, Linear discriminant analysis.	
	6.2	Non-Linear Dimensionality Reduction: Multidimensional Scaling, Isometric Feature Mapping. Minimal polynomial	
		Total	**48**

Text Books:

1 Linear Algebra for Everyone,
2 Gilbert Strang, Wellesley Cambridge Press.
3 An Introduction to Probability and Statistics, Vijay Rohatgi, Wiley Publication
4 An introduction to Optimization, Second Edition, Wiley-Edwin Chong, Stainslaw Zak.
5 Mathematics for Machine Learning, Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, Cambridge University Press.
6 Exploratory Data Analysis, John Tukey, Princeton University and Bell Laboratories.

References:

1 Introduction to Linear Algebra, Gilbert Strang.
2 Advanced Engineering Mathematics, Erwin Kreyszig
3 Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar. Foundations of Machine Learning. MIT Press, 2018.
4 Shai Shalev-Shwartz and Shai Ben-David. Understanding Machine Learning: From Theory to Algorithms. Cambridge University Press, 2014
5 Last updated on Sep 9, 2018.
6 Mathematics and Programming for Machine Learning with R, William B. Claster, CRC Press,2020

Useful Links:

1 https://math.mit.edu/~gs/linearalgebra/
2 https://www.coursera.org/learn/probability-theory-statistics
3 https://nptel.ac.in/courses/111/105/111105090/
4 https://onlinecourses.nptel.ac.in/noc21_ma01/preview
5 https://ocw.mit.edu/courses/mathematics/18-06-linear-algebra-spring-2010/video-lectures/

Assessment:

Internal Assessment: (20)

1 Assessment consists of two class tests of 20 marks each.

2 The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.
3 Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3 Remaining questions will be mixed in nature and randomly selected from all the modules.
4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5 **Total 04 questions** need to be solved.

Artificial Intelligence and Machine Learning: Sem VI								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HAIMLC601	**Game Theory using AI & ML**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Practical and Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HAIMLC601	**Game Theory using AI & ML**	**20**	**20**	**20**	**80**	**03**	**--**	**--**	**100**

Course Prerequisites:	
Knowledge of probability theory, discrete mathematics, and algorithm design is required.	
Course Objectives:	
1	To acquire the knowledge of game theory.
2	To understand the basic concept of AI, strength and weakness of problem solving and search
3	To study about various heuristic and game search algorithms
4	To optimize the different linear methods of regression and classification
5	To interpret the different supervised classification methods of support vector machine.
6	To acquire the knowledge of different generative models through unsupervised learning
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Understand basic concept of game theory.
2	Evaluate Artificial Intelligence (AI) methods and describe their foundations
3	Analyze and illustrate how search algorithms play vital role in problem solving, inference, perception, knowledge representation and learning
4	Demonstrate knowledge of reasoning and knowledge representation for solving real world problems
5	Recognize the characteristics of machine learning that makes it useful to realworld problems and apply different dimensionality reduction techniques
6	Apply the different supervised learning methods of support vector machine and tree based models

Module No.		**Topics**	**Hours.**
1.0		**Introduction to Game Theory**	**05**
	1.1	Introduction, The theory of rational choice, Games with Perfect Information, Nash Equilibrium: Theory, Prisoner's Dilemma, Stag Hunt, Matching pennies, BOS, Multi NE, Cooperative and Competitive Games, Strict and Non Strict NE, Best response functions for NE.	
	1.2	Nash Equilibrium: Illustrations, Cournot's model of oligopoly, Bertrand's model of oligopoly, Electoral competition, The War of Attrition, Auctions, Mixed Strategy Equilibrium, Strategic games in which players may randomize, Dominated actions, Extensive Games with Perfect Information	

2.0		**Games with Imperfect Information**	**09**
	2.1	Bayesian Games, Introduction, Motivational examples, General definitions, two examples concerning information, Strictly Competitive Games and Maxminimization, Rationalizability	
	2.2	Evolutionary Equilibrium, Monomorphic pure strategy equilibrium, Mixed strategies and polymorphic equilibrium, Repeated games: The Prisoner's Dilemma, Infinitely repeated games, Strategies, General Results,	
3.0		**Introduction to AI & Problem Solving**	**10**
	3.1	**Definitions** – Foundation and History of AI, Evolution of AI - Applications of AI, Classification of AI systems with respect to environment. Artificial Intelligence vs Machine learning,	
	3.2	**Heuristic Search Techniques:** Generate-and-Test; Hill Climbing; Properties of A* algorithm, Best first Search; Problem Reduction.	
	3.3	**Beyond Classical Search:** Local search algorithms and optimization problem, local search in continuous spaces, searching with nondeterministic action and partial observation, online search agent and unknown environments	
4.0		**Knowledge and Reasoning**	**09**
	4.1	**Knowledge and Reasoning:** Building a Knowledge Base: Propositional logic, first order Logic, situation calculus. Theorem Proving in First Order Logic, Planning, partial order planning. Uncertain Knowledge and Reasoning, Probabilities,	
	4.2	Bayesian Networks. Probabilistic reasoning over time: time and uncertainty, hidden Markova models, Kalman filter, dynamic bayesian network, keeping track of many objects	
5.0		**Introduction to ML**	**10**
	5.1	Introduction to Machine Learning, Examples of Machine Learning Applications, Learning Types, **Supervised Learning** -Learning a Class from Examples, Vapnik- Chervonenkis (VC) Dimension, Probably Approximately Correct (PAC) Learning, Noise, Learning Multiple Classes, Regression, Model Selection and Generalization, Dimensions of a Supervised Machine Learning Algorithm	
	5.2	Introduction, Linear Regression Models and Least Squares, Subset Selection, Shrinkage Methods, **Logistic Regression-** Fitting Logistic Regression Models, Quadratic Approximations and Inference, L1 Regularized Logistic Regression, **SVM**-Introduction to SVM, The Support Vector Classifier, Support Vector Machines and Kernels- Computing the SVM for Classification	
6.0		**Unsupervised Learning**	**05**
	6.1	Introduction, Association Rules-Market Basket Analysis, The Apriori Algorithm, Unsupervised as Supervised Learning, Generalized Association Rules, Cluster Analysis Proximity Matrices, **Clustering Algorithms**-K-mean, Gaussian Mixtures as Soft K-means Clustering, Example: Human Tumor Microarray Data, Vector Quantization, K-medoids, Hierarchical Clustering, Self-Organizing Maps, PCA-Spectral Clustering	
	6.2	**Hidden Markov Models**-Introduction, Discrete Markov Processes, Hidden Markov Models, Three Basic Problems of HMMs, Evaluation Problem, Finding the State Sequence, Learning Model Parameters, Continuous Observations, The HMM with Input, Model Selection in HMM	
		Total	**48**

Text Books:

1 Martin Osborne, An Introduction to Game Theory, Oxford University Press.
2 Russell, S. and Norvig, P. 2015. Artificial Intelligence - A Modern Approach, 3rd edition,Prentice Hall
3 Introduction to Machine Learning Edition 2, by Ethem Alpaydin

References:

1 Thomas Ferguson, Game Theory, World Scientific, 2018.
2 Stef Tijs. Introduction to Game Theory, Hindustan Book Agency
3 J. Gabriel, Artificial Intelligence: Artificial Intelligence for Humans (Artificial Intelligence, Machine Learning), Create Space Independent Publishing Platform, First edition , 2016
4 Introduction to Artificial Intelligence & Expert Systems, Dan W Patterson, PHI.,2010 2. S Kaushik, Artificial Intelligence, Cengage Learning, 1st ed.2011
5 Machine Learning. Tom Mitchell. First Edition, McGraw- Hill, 1997

Assessment:

Internal Assessment: (20)

1 Assessment consists of two class tests of 20 marks each.
2 The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.
3 Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3 Remaining questions will be mixed in nature and randomly selected from all the modules.
4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5 **Total 04 questions** need to be solved.

Artificial Intelligence and Machine Learning: Sem VII								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HAIMLC701	**AI&ML in Healthcare**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Practical and Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HAIMLC701	**AI&ML in Healthcare**	**20**	**20**	**20**	**80**	**03**	**--**	**--**	**100**

Course Prerequisites:	
Artificial Intelligence, Machine Learning	
Course Objectives: The course aims	
1	To understand the need and significance of AI and ML for Healthcare.
2	To study advanced AI algorithms for Healthcare.
3	To learn Computational Intelligence techniques .
4	To understand evaluation metrics and ethics in intelligence for Healthcare systems,
5	To learn various NLP algorithms and their application in Healthcare,
6	To investigate the current scope, implications of AI and ML for developing futuristic Healthcare Applications.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Understand the role of AI and ML for handling Healthcare data.
2	Apply Advanced AI algorithms for Healthcare Problems.
3	Learn and Apply various Computational Intelligence techniques for Healthcare Application.
4	Use evaluation metrics for evaluating healthcare systems.
5	Develop NLP applications for healthcare using various NLP Techniques..
6	Apply AI and ML algorithms for building Healthcare Applications

Module		**Topics**	**Hours.**
1.0		**Introduction**	**04**
	1.1	Overview of AI and ML,A Multifaceted Discipline, Applications of AI in Healthcare - Prediction, Diagnosis, personalized treatment and behavior modification, drug discovery, followup care etc,	
	1.2	Realizing potential of AI and ML in healthcare, Healthcare Data - Use Cases.	
2.0		**AI, ML, Deep Learning and Data Mining Methods for Healthcare**	10
	2.1	Knowledge discovery and Data Mining, ML, Multi classifier Decision Fusion, Ensemble Learning, Meta-Learning and other Abstract Methods.	
	2.2	Evolutionary Algorithms, Illustrative Medical Application-Multiagent Infectious Disease Propagation and Outbreak Prediction, Automated Amblyopia Screening System etc.	
	2.3	Computational Intelligence Techniques, Deep Learning, Unsupervised learning, dimensionality reduction algorithms.	

3.0		**Evaluating learning for Intelligence**	06
	3.1	Model development and workflow, evaluation metrics, Parameters and Hyperparameters, Hyperparameter tuning algorithms, multivariate testing, Ethics of Intelligence.	
4.0		**Natural Language Processing in Healthcare**	**08**
	4.1	NLP tasks in Medicine, Low-level NLP components, High level NLP components, NLP Methods.	
	4.2	Clinical NLP resources and Tools, NLP Applications in Healthcare. Model Interpretability using Explainable AI for NLP applications.	
5.0		**Intelligent personal Health Record**	**04**
	5.1	Introduction, Guided Search for Disease Information, Recommending SCA's. Recommending HHP's , Continuous User Monitoring.	
6.0		**Future of Healthcare using AI and ML**	**07**
	6.1	Evidence based medicine, Personalized Medicine, Connected Medicine, Digital Health and Therapeutics, Conversational AI, Virtual and Augmented Reality, Blockchain for verifying supply chain, patient record access, Robot - Assisted Surgery, Smart Hospitals, Case Studies on use of AI and ML for Disease Risk Diagnosis from patient data, Augmented reality applications for Junior doctors.	
	6.2	Blockchain for verifying supply chain, patient record access, Robot - Assisted Surgery, Smart Hospitals, Case Studies on use of AI and ML for Disease Risk Diagnosis from patient data, Augmented reality applications for Junior doctors.	
		Total	**48**

Textbooks:

1 Arjun Panesar, "Machine Learning and AI for Healthcare", A Press.

2 Arvin Agah, "Medical applications of Artificial Systems ", CRC Press

References:

1 Erik R. Ranschaert Sergey Morozov Paul R. Algra, "Artificial Intelligence in medical Imaging-Opportunities, Applications and Risks", Springer

2 Sergio Consoli Diego Reforgiato Recupero Milan Petković,"Data Science for Healthcare-Methodologies and Applications", Springer

3 Dac-Nhuong Le, Chung Van Le, Jolanda G. Tromp, Gia Nhu Nguyen, "Emerging technologies for health and medicine", Wiley.

4 Ton J. Cleophas • Aeilko H. Zwinderman, "Machine Learning in Medicine- Complete Overview", Springer

Assessment:

Internal Assessment: (20)

1 Assessment consists of two class tests of 20 marks each.

2 The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.

3 Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.

2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.

3 Remaining questions will be mixed in nature and randomly selected from all the modules.

4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

5 **Total 04 questions** need to be solved.

Artificial Intelligence and Machine Learning: Sem VIII								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HAIMLC801	**Text, Web and Social Media Analytics**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Practical and Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HAIMLC801	**Text, Web and Social Media Analytics**	**20**	**20**	**20**	**80**	**03**	**--**	**--**	**100**

Course Prerequisites:	
Python, Data Mining	
Course Objectives: The course aims	
1	To have a strong foundation on text, web and social media analytics.
2	To understand the complexities of extracting the text from different data sources and analysing it.
3	To enable students to solve complex real-world problems using sentiment analysis and Recommendation systems.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Extract Information from the text and perform data pre-processing
2	Apply clustering and classification algorithms on textual data and perform prediction.
3	Apply various web mining techniques to perform mining, searching and spamming of web data.
4	Provide solutions to the emerging problems with social media using behaviour analytics and Recommendation systems.
5	Apply machine learning techniques to perform Sentiment Analysis on data from social media.

Module		**Topics**	**Hours.**
1.0		**Introduction**	**06**
	1.1	**Introduction to Text Mining:** Introduction, Algorithms for Text Mining, Future Directions	
	1.2	**Information Extraction from Text**: Named Entity Recognition, Relation Extraction, Unsupervised Information Extraction	
	1.3	**Text Representation:** tokenization, stemming, stop words, NER, N-gram modelling	
2.0		Clustering and Classification	10

	2.1	**Text Clustering**: Feature Selection and Transformation Methods, distance based Clustering Algorithms, Word and Phrase based Clustering, Probabilistic document Clustering	
	2.2	**Text Classification**: Feature Selection, Decision tree Classifiers, Rule-based Classifiers, Probabilistic based Classifiers, Proximity based Classifiers.	
	2.3	**Text Modelling:** Bayesian Networks, Hidden Markovian Models, Markov random Fields, Conditional Random Fields	
3.0		**Web-Mining:**	05
	3.1	**Introduction to Web-Mining:** Inverted indices and Compression, Latent Semantic Indexing, Web Search,	
	3.2	**Meta Search:** Using Similarity Scores, Rank Positons	
	3.3	**Web Spamming**: Content Spamming, Link Spamming, hiding Techniques, and Combating Spam	
4.0		**Web Usage Mining:**	**05**
	4.1	Data Collection and Pre-processing, Sources and types of Data, Data Modelling, Session and Visitor Analysis, Cluster Analysis and Visitor segmentation, Association and Correlation Analysis, Analysis of Sequential and Navigational Patterns, Classification and Prediction based on Web User Transactions.	
5.0		**Social Media Mining**:	**05**
	5.1	Introduction, Challenges, Types of social Network Graphs	
	5.2	Mining Social Media: Influence and Homophily, Behaviour Analytics, Recommendation in Social Media: Challenges, Classical recommendation Algorithms, Recommendation using Social Context, Evaluating recommendations.	
6.0		**Opinion Mining and Sentiment Analysis**:	**08**
	6.1	The problem of opinion mining,	
	6.2	**Document Sentiment Classification**: Supervised, Unsupervised	
	6.3	**Opinion Lexicon Expansion:** Dictionary based, Corpus based	
	6.4	**Opinion Spam Detection**: Supervised Learning, Abnormal Behaviours, Group Spam Detection.	
		Total	**48**

Textbooks:

1 Daniel Jurafsky and James H. Martin, “Speech and Language Processing,” 3rd edition, 2020

2 Charu. C. Aggarwal, Cheng Xiang Zhai, Mining Text Data, Springer Science and Business Media, 2012.

3 BingLiu, “Web Data Mining-Exploring Hyperlinks, Contents, and Usage Data”, Springer, Second Edition, 2011.

4 Reza Zafarani, Mohammad Ali Abbasiand Huan Liu, “Social Media Mining- An Introduction”, Cambridge University Press, 2014

Assessment:

Internal Assessment: (20)

1 Assessment consists of two class tests of 20 marks each.
2 The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.
3 Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3 Remaining questions will be mixed in nature and randomly selected from all the modules.
4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5 **Total 04 questions** need to be solved.

Artificial Intelligence and Machine Learning:Sem VII								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HAIMLSBL701	**AI&ML in Healthcare: Lab**	**--**	**04**	**--**	**--**	**02**	**--**	**02**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HAIMLSBL701	**AI&ML in Healthcare: Lab**						**50**	**50**	**100**

Course Prerequisites:	
Python	
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Students will be able to understand computational models of AI and ML.
2	Students will be able to develop healthcare applications using appropriate computational tools.
3	Students will be able to apply appropriate models to solve specific healthcare problems.
4	Students will be able to analyze and justify the performance of specific models as applied to healthcare problems.
5	Students will be able to design and implement AI and ML-based healthcare applications.

Suggested Experiments:	
Sr. No.	**Name of the Experiment**
1	Collect, Clean, Integrate and Transform Healthcare Data based on specific disease.
2	Perform Exploratory data analysis of Healthcare Data.
3	AI for medical diagnosis based on MRI/X-ray data.
4	AI for medical prognosis .
5	Natural language Entity Extraction from medical reports.
6	Predict disease risk from Patient data.
7	Medical Reviews Analysis from social media data.
8	Explainable AI in healthcare for model interpretation.
9	Mini Project-Design and implement innovative web/mobile based AI application using Healthcare Data.
10	Documentation and Presentation of Mini Project.

Useful Links:

1. https://www.coursera.org/learn/introduction-tensorflow?specialization=tensorflow-in-practice
2. https://www.coursera.org/learn/convolutional-neural-networks-tensorflow?specialization=tensorflow-in-practice
3. https://datarade.ai/data-categories/electronic-health-record-ehr-data
4. https://www.cms.gov/Medicare/E-Health/EHealthRecords
5. https://www.coursera.org/learn/tensorflow-sequences-time-series-and-prediction?specialization=tensorflow-in-practice

Term Work:

1. Term work should consist of 8 experiments and a Mini Project.
2. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3. Total 25 Marks (Experiments: 10-Marks, Mini Project-10 Marks, Attendance Theory & Practical: 05-marks)

Oral & Practical exam

1. Based on the entire syllabus of **AI ML for Healthcare**

University of Mumbai

Syllabus for

Honours/Minor Degree Program

In

Data Science

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Data Science (With effect from 2022-23)										
Year & Sem	Course Code & Course Title	Teaching Scheme Hrs / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar / Tutorial	Practical	Internal Assessment	End Sem Exam	Term Work	Oral	Total	Credits
TE Sem V	HDSC501: Mathematics for Data Science	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**	**-**	**-**	**-**	**100**	**04**
										Total Credits = 04
TE Sem VI	HDSC601: Statistical Learning for Data Science	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**	**-**	**-**	**-**	**100**	**04**
										Total Credits = 04
BE Sem VII	HDSC701: Data Science for Health and Social Care	04	--	--	20	80	--	--	100	04
	HDSSBL701: Data Science for Health and Social Care: Lab	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
										Total Credits = 06
BE Sem VIII	HDSC801: Text, Web and Social Media Analytics	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
										Total Credits = 04
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04 = 18										

Data Science: Sem V								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HDSC501	**Mathematics for Data Science**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Practical and Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HDSC501	**Mathematics for Data Science**	**20**	**20**	**20**	**80**	**03**	**--**	**--**	**100**

Course Prerequisites:	
1	Applied Mathematics, Discrete Mathematics
Course Objectives:	
1	To build an intuitive understanding of Mathematics and relating it to Data Analytics.
2	To provide a strong foundation for probabilistic and statistical analysis mostly used in varied applications in Engineering.
3	To focus on exploring the data with the help of graphical representation and drawing conclusions.
4	To explore optimization and dimensionality reduction techniques.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Use linear algebra concepts to model, solve, and analyze real-world problems.
2	Apply probability distributions and sampling distributions to various business problems.
3	Select an appropriate graph representation for the given data analysis.
4	Apply exploratory data analysis to some real data sets and provide interpretations via relevant visualization
5	Analyze various optimization techniques for data analysis.
6	Describe Dimension Reduction Algorithms in analytics

Module		**Topics**	**Hours.**
1.0		**Linear Algebra**	**05**
	1.1	Vectors and Matrices, Solving Linear equations, The four Fundamental Subspaces, Eigenvalues and Eigen Vectors, The Singular Value Decomposition (SVD).	
2.0		**Probability and Statistics**	**09**
	2.1	Introduction, Random Variables and their probability Distribution, Random Sampling, Sample Characteristics and their Distributions, Chi-Square, t-, and F-Distributions: Exact Sampling Distributions, Sampling from a Bivariate Normal Distribution, The Central Limit Theorem.	
3.0		**Introduction to Graphs**	**10**
	3.1	Quantitative vs. Qualitative data, Types of Quantitative data: Continuous data, Discrete data, Types of Qualitative data: Categorical data, Binary data, Ordinary data, Plotting	

		data using Bar graph, Pie chart, Histogram, Stem and Leaf plot, Dot plot, Scatter plot, Time-series graph, Exponential graph, Logarithmic graph, Trigonometric graph, Frequency distribution graph.	
4.0		**Exploratory Data Analysis**	**09**
	4.1	Need of exploratory data analysis, cleaning and preparing data, Feature engineering, Missing values, understand dataset through various plots and graphs, draw conclusions, deciding appropriate machine learning models.	
5.0		**Optimization Techniques**	**10**
	5.1	Types of optimization-Constrained and Unconstrained optimization, Methods of Optimization-Numerical Optimization, Bracketing Methods-Bisection Method, False Position Method, Newton's Method, Steepest Descent Method, Penalty Function Method.	
6.0		**Dimension Reduction Algorithms**	**05**
	6.1	Introduction to Dimension Reduction Algorithms, Linear Dimensionality Reduction: Principal component analysis, Factor Analysis, Linear discriminant analysis.	
	6.2	Non-Linear Dimensionality Reduction: Multidimensional Scaling, Isometric Feature Mapping. Minimal polynomial	
		Total	**48**

Text Books:

1 Linear Algebra for Everyone,
2 Gilbert Strang, Wellesley Cambridge Press.
3 An Introduction to Probability and Statistics, Vijay Rohatgi, Wiley Publication
4 An introduction to Optimization, Second Edition, Wiley-Edwin Chong, Stainslaw Zak.
5 Mathematics for Machine Learning, Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, Cambridge University Press.
6 Exploratory Data Analysis, John Tukey, Princeton University and Bell Laboratories.

References:

1 Introduction to Linear Algebra, Gilbert Strang.
2 Advanced Engineering Mathematics, Erwin Kreyszig
3 Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar. Foundations of Machine Learning. MIT Press, 2018.
4 Shai Shalev-Shwartz and Shai Ben-David. Understanding Machine Learning: From Theory to Algorithms. Cambridge University Press, 2014
5 Last updated on Sep 9, 2018.
6 Mathematics and Programming for Machine Learning with R, William B. Claster, CRC Press,2020

Useful Links:

1 https://math.mit.edu/~gs/linearalgebra/
2 https://www.coursera.org/learn/probability-theory-statistics
3 https://nptel.ac.in/courses/111/105/111105090/
4 https://onlinecourses.nptel.ac.in/noc21_ma01/preview
5 https://ocw.mit.edu/courses/mathematics/18-06-linear-algebra-spring-2010/video-lectures/

Assessment:

Internal Assessment: (20)

1 Assessment consists of two class tests of 20 marks each.
2 The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.

3 Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3 Remaining questions will be mixed in nature and randomly selected from all the modules.
4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5 **Total 04 questions** need to be solved.

Data Science: Sem VI								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HDSC601	**Statistical Learning for Data Science**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Practical and Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HDSC601	**Statistical Learning for Data Science**	**20**	**20**	**20**	**80**	**03**	**--**	**--**	**100**

Course Prerequisites:	
1	Engineering Mathematics, Probability and Statistics
Course Objectives:	
1	To understand basic statistical foundations for roles of Data Scientist.
2	To develop problem-solving skills.
3	To infer about the population parameters using sample data and perform hypothesis testing.
4	To understand importance and techniques of predicting a relationship between data and determine the goodness of model fit.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Develop various visualizations of the data in hand.
2	Analyze a real-world problem and solve it with the knowledge gained from sampling and probability distributions.
3	Analyze large data sets and perform data analysis to extract meaningful insights.
4	Develop and test a hypothesis about the population parameters to draw meaningful conclusions.
5	Fit a regression model to data and use it for prediction.

Module No.		**Topics**	**Hours.**
1.0		**Introduction**	**08**
	1.1	**Data and Statistics**: Elements, Variables, and Observations, Scales of Measurement, Categorical and Quantitative Data, Cross-Sectional and Time Series Data, Descriptive Statistics, Statistical Inference, Descriptive Statistics: Tabular and Graphical Summarizing Categorical Data, Summarizing Quantitative Data, Cross Tabulations and Scatter Diagram.	
	1.2	**Descriptive Statistics: Numerical Measures**: Measures of Location, Measures of Variability, Measures of Distribution Shape, Relative Location, and Detecting Outliers, Box Plot, Measures of Association Between Two Variables	

2.0		**Probability**	**08**
	2.1	**Probability :** Experiments, Counting Rules, and Assigning Probabilities, Events and Their Probabilities, Complement of an Event, Addition Law Independent Events, Multiplication Law, Baye's theorem	
	2.2	**Discrete Probability Distributions** Random Variables, Discrete Probability Distributions, Expected Value and Variance, Binomial Probability Distribution, Poisson Probability Distribution	
	2.3	**Continuous Probability Distributions:** Uniform Probability Distribution, Normal Curve, Standard Normal Probability Distribution, Computing Probabilities for Any Normal Probability Distribution	
3.0		**Sampling and Sampling Distributions**	05
	3.1	Sampling from a Finite Population, Sampling from an Infinite Population, Other Sampling Methods, Stratified Random Sampling, Cluster Sampling, Systematic Sampling, Convenience Sampling, Judgment Sampling	
	3.2	Interval Estimation: Population Mean: Known, Population Mean: Unknown, Determining the Sample Size, Population Proportion	
4.0		**Hypothesis Tests**	**05**
	4.1	Developing Null and Alternative Hypotheses, Type I and Type II Errors, Population Mean: Known Population Mean: Unknown Inference About Means and Proportions with Two Populations-Inferences About Population Variances, Inferences About a Population Variance, Inferences About Two Population Variances	
	4.2	Tests of Goodness of Fit and Independence, Goodness of Fit Test: A Multinomial Population, Test of Independence	
5.0		**Regression**	**08**
	5.1	**Simple Linear Regression:** Simple Linear Regression Model, Regression Model and Regression Equation, Estimated Regression Equation, Least Squares Method, Coefficient of Determination, Correlation Coefficient, Model Assumptions, testing for Significance, Using the Estimated Regression Equation for Estimation and Prediction Residual Analysis: Validating Model Assumptions, Residual Analysis: Outliers and Influential Observations	
	5.2	**Multiple Regression:** Multiple Regression Model, Least Squares Method, Multiple Coefficient of Determination, Model Assumptions, Testing for Significance, Categorical Independent Variables, Residual Analysis	
6.0		**Time Series Analysis and Forecasting**	**05**
	6.1	Time Series Patterns, Forecast Accuracy, Moving Averages and Exponential Smoothing, Trend Projection, Seasonality and Trend and Time Series Decomposition	
	6.2	**Nonparametric Methods** Sign Test, Wilcoxon Signed-Rank Test, Mann-Whitney-Wilcoxon Test, Kruskal-Wallis Test, Rank Correlation	
		Total	**48**

Text Books:

1. https://static1.squarespace.com/static/5ff2adbe3fe4fe33db902812/t/6009dd9fa7bc363aa822d2c7/1611259312432/ISLR+Seventh+Printing.pdf
2. Data Science from Scratch, FIRST PRINCIPLES WITH PYTHON, O'Reilly, Joel Grus,
3. Data Science from Scratch (oreillystatic.com)
4. Practical Time Series Analysis, Prediction with statistics and Machine Learning, O'Reilly, Aileen Nielsen [DOWNLOAD] O'Reilly Practical Time Series Analysis PDF (lunaticai.com)
5. R for data science: Import, Tidy, Transform, Visualize, And Model Data, O'Reilly , Garrett Grolemund, Hadley Wickham
6. Python for Data Analysis, 2nd Edition, O'Reilly Media, Wes McKinney.
7. https://static1.squarespace.com/static/5ff2adbe3fe4fe33db902812/t/6009dd9fa7bc363aa822d2c7/1611259312432/ISLR+Seventh+Printing.pdf

References:

1. Data Science for Dummies Paperback, Wiley Publications, Lillian Pierson
2. Storytelling with Data: A Data Visualization, Guide for Business Professionals, Wiley Publications, Cole Nussbaumer Knaflic
3. Probability and Statistics for Engineering and the Sciences, Cengage Publications Jay L. Devore.

Assessment:

Internal Assessment: (20)

1. Assessment consists of two class tests of 20 marks each.
2. The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.
3. Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1. Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2. **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3. Remaining questions will be mixed in nature and randomly selected from all the modules.
4. Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5. **Total 04 questions** need to be solved.

Data Science: Sem VII								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HDSC701	**Data Science for Health and Social Care**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HDSC701	**Data Science for Health and Social Care**	**20**	**20**	**20**	**80**	**03**	**--**	**--**	**100**

Course Prerequisites:	
Artificial Intelligence, Machine Learning	
Course Objectives: The course aims	
1	To gain perspective of Data Science for Health and Social Care.
2	To understand different techniques of Biomedical Image Analysis.
3	To learn NLP techniques for processing Clinical text.
4	To understand the role of social media analytics for Healthcare data .
5	To learn advanced analytics techniques for Healthcare Data.
6	To investigate the current scope, potential, limitations, and implications of data science and its applications for healthcare.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Identify sources and structure of healthcare data.
2	Apply structured lifecycle approach for handling Healthcare data science projects.
3	Analyze the data, create models, and identify insights from Healthcare data.
4	Apply various data analysis and visualization techniques for Healthcare and social media data.
5	Apply various algorithms and develop models for Healthcare data science projects.
6	To Provide data science solutions for solving problems of Health and Social Care.

Module		**Topics**	**Hours.**
1.0		**Data Science for Healthcare**	**05**
	1.1	Introduction, Healthcare Data Sources and Data Analytics for Healthcare, Applications and Practical Systems for Healthcare.	
	1.2	Electronic Health Records(EHR), Components of EHR, Benefits of EHR, Barriers to Adopting EHR, Challenges of using EHR data, Phenotyping Algorithms	
2.0		**Biomedical Image Analysis**	06
	2.1	Biomedical Imaging Modalities, Object detection ,Image segmentation, Image Registration, Feature Extraction	
	2.2	Mining of Sensor data in Healthcare, Challenges in Healthcare Data Analysis	
	2.3	Biomedical Signal Analysis, Genomic Data Analysis for Personalized Medicine.	
3.0		**Data Science and Natural Language Processing for Clinical Text**	06

	3.1	NLP, Mining information from Clinical Text, Information Extraction, Rule Based Approaches, Pattern based algorithms, Machine Learning Algorithms.	
	3.2	Clinical Text Corpora and evaluation metrics, challenges in processing clinical reports, Clinical Applications.	
4.0		**Social Media Analytics for Healthcare**	**06**
	4.1	Social Media analysis for detection and tracking of Infectious Disease outbreaks.	
	4.2	Outbreak detection, Social Media Analysis for Public Health Research, Analysis of Social Media Use in Healthcare.	
5.0		**Advanced Data Analytics for Healthcare**	**08**
	5.1	Review of Clinical Prediction Models, Temporal Data Mining for Healthcare Data	
	5.2	Visual Analytics for Healthcare Data, Information Retrieval for Healthcare- Data Publishing Methods in Healthcare.	
6.0		**Data Science Practical Systems for Healthcare**	**08**
	6.1	Data Analytics for Pervasive Health, Fraud Detection in Healthcare	
	6.2	Data Analytics for Pharmaceutical discoveries, Clinical Decision Support Systems	
	6.3	Computer-Assisted Medical Image Analysis Systems- Mobile Imaging and Analytics for Biomedical Data.	
		Total	**48**

Textbooks:

1 Chandan K. Reddy and Charu C Aggarwal, “Healthcare data analytics”, Taylor & Francis, 2015.

2 Hui Yang and Eva K. Lee, “Healthcare Analytics: From Data to Knowledge to Healthcare Improvement, Wiley, 2016.

References:

1 Madsen, L. B. (2015). Data-driven healthcare: how analytics and BI are transforming the industry. Wiley India Private Limited

2 Strome, T. L., & Liefer, A. (2013). Healthcare analytics for quality and performance improvement. Hoboken, NJ, USA: Wiley

3 McNeill, D., & Davenport, T. H. (2013). Analytics in Healthcare and the Life Sciences: Strategies, Implementation Methods, and Best Practices. Pearson Education.

4 Rachel Schutt and Cathy O’Neil, “Doing Data Science”, O’Reilly Media

5 Joel Grus, Data Science from Scratch: First Principles with Python, O'Reilly Media

6 EMC Education Services,”Data Science and Big Data Analytics”,Wiley

Assessment:

Internal Assessment: (20)

1 Assessment consists of two class tests of 20 marks each.

2 The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.

3 Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.

2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.

3 Remaining questions will be mixed in nature and randomly selected from all the modules.

4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.

5 **Total 04 questions** need to be solved.

Data Science: Sem VIII								
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
HDSC801	Text, Web and Social Media Analytics	04	--	--	04	--	--	04

Course Code	Course Name	Examination Scheme							
		Theory Marks				Exam Duration	Term Work	Practical and Oral	Total
		Internal Assessment			End Sem. Exam.				
		Test1	Test2	Avg.					
HDSC801	Text, Web and Social Media Analytics	20	20	20	80	03	--	--	100

Course Prerequisites:	
Python, Data Mining	
Course Objectives: The course aims	
1	To have a strong foundation on text, web and social media analytics.
2	To understand the complexities of extracting the text from different data sources and analysing it.
3	To enable students to solve complex real-world problems using sentiment analysis and Recommendation systems.
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Extract Information from the text and perform data pre-processing
2	Apply clustering and classification algorithms on textual data and perform prediction.
3	Apply various web mining techniques to perform mining, searching and spamming of web data.
4	Provide solutions to the emerging problems with social media using behaviour analytics and Recommendation systems.
5	Apply machine learning techniques to perform Sentiment Analysis on data from social media.

Module No.		Topics	Hours.
1.0		**Introduction**	**06**
	1.1	**Introduction to Text Mining:** Introduction, Algorithms for Text Mining, Future Directions	
	1.2	**Information Extraction from Text**: Named Entity Recognition, Relation Extraction, Unsupervised Information Extraction	
	1.3	**Text Representation:** tokenization, stemming, stop words, NER, N-gram modelling	
2.0		Clustering and Classification	10

	2.1	**Text Clustering**: Feature Selection and Transformation Methods, distance based Clustering Algorithms, Word and Phrase based Clustering, Probabilistic document Clustering	
	2.2	**Text Classification**: Feature Selection, Decision tree Classifiers, Rule-based Classifiers, Probabilistic based Classifiers, Proximity based Classifiers.	
	2.3	**Text Modelling:** Bayesian Networks, Hidden Markovian Models, Markov random Fields, Conditional Random Fields	
3.0		**Web-Mining:**	05
	3.1	**Introduction to Web-Mining:** Inverted indices and Compression, Latent Semantic Indexing, Web Search,	
	3.2	**Meta Search:** Using Similarity Scores, Rank Positons	
	3.3	**Web Spamming**: Content Spamming, Link Spamming, hiding Techniques, and Combating Spam	
4.0		**Web Usage Mining:**	**05**
	4.1	Data Collection and Pre-processing, Sources and types of Data, Data Modelling, Session and Visitor Analysis, Cluster Analysis and Visitor segmentation, Association and Correlation Analysis, Analysis of Sequential and Navigational Patterns, Classification and Prediction based on Web User Transactions.	
5.0		**Social Media Mining**:	**05**
	5.1	Introduction, Challenges, Types of social Network Graphs	
	5.2	Mining Social Media: Influence and Homophily, Behaviour Analytics, Recommendation in Social Media: Challenges, Classical recommendation Algorithms, Recommendation using Social Context, Evaluating recommendations.	
6.0		**Opinion Mining and Sentiment Analysis**:	**08**
	6.1	The problem of opinion mining,	
	6.2	**Document Sentiment Classification**: Supervised, Unsupervised	
	6.3	**Opinion Lexicon Expansion:** Dictionary based, Corpus based	
	6.4	**Opinion Spam Detection**: Supervised Learning, Abnormal Behaviours, Group Spam Detection.	
		Total	**48**

Textbooks:

1 Daniel Jurafsky and James H. Martin, “Speech and Language Processing,” 3rd edition, 2020

2 Charu. C. Aggarwal, Cheng Xiang Zhai, Mining Text Data, Springer Science and Business Media, 2012.

3 BingLiu, “Web Data Mining-Exploring Hyperlinks, Contents, and Usage Data”, Springer, Second Edition, 2011.

4 Reza Zafarani, Mohammad Ali Abbasiand Huan Liu, “Social Media Mining- An Introduction”, Cambridge University Press, 2014

Assessment:

Internal Assessment: (20)

1 Assessment consists of two class tests of 20 marks each.
2 The first-class test is to be conducted when approx. 40% syllabus is completed and second-class test when additional 40% syllabus is completed.
3 Duration of each test shall be one hour.

End Semester Theory Examination: (80)

1 Question paper will comprise of **total 06** questions, each carrying **20 marks**.
2 **Question No: 01** will be **compulsory** and based on the entire syllabus wherein 4 to 5 sub-questions will be asked.
3 Remaining questions will be mixed in nature and randomly selected from all the modules.
4 Weightage of each module will be proportional to number of respective lecture hours as mentioned in the syllabus.
5 **Total 04 questions** need to be solved.

Data Science: Sem VII								
Course Code	**Course Name**	**Teaching Scheme (Contact Hours)**			**Credits Assigned**			
		Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
HDSSBL701	**Data Science for Health and Social Care: Lab**	**--**	**04**	**--**	**--**	**02**	**--**	**02**

Course Code	**Course Name**	**Examination Scheme**							
		Theory Marks				**Exam Duration**	**Term Work**	**Oral**	**Total**
		Internal Assessment			**End Sem. Exam.**				
		Test1	**Test2**	**Avg.**					
HDSSBL701	**Data Science for Health and Social Care: Lab**						**50**	**50**	**100**

Course Prerequisites:	
Python	
Course Outcomes:	
After successful completion of the course, the student will be able to:	
1	Students will be able to, Identify sources of data, suggest methods for collecting, sharing and analyzing Healthcare data.
2	Students will be able to Clean, integrate and transform healthcare data.
3	Students will be able to apply various data analysis and visualization techniques on healthcare data.
4	Students will be able to apply various algorithms and develop models for healthcare data Analytics.
5	Students will be able to implement data science solutions for solving healthcare problems.

Suggested Experiments:	
Sr. No.	**Name of the Experiment**
	Introduction
1	Clean, Integrate and Transform Electronic Healthcare Records.
2	Apply various data analysis and visualization techniques on EHR.
3	Bio Medical Image Preprocessing, Segmentation.
4	Bio Medical Image Analytics.
5	Text Analytics for Clinical Text Data.
6	Diagnose disease risk from Patient data.
7	Social Media Analytics for outbreak prediction/ Drug review analytics.
8	Visual Analytics for Healthcare Data.

9	Implement an innovative Data Science application based on Healthcare Data.
10	Documentation and Presentation of Mini Project.

Useful Links:

1. http://openclassroom.stanford.edu/MainFolder/CoursePage.php?course=MachineLearning
2. http://www.cse.wustl.edu/~kilian/cse517a2010/
3. https://datarade.ai/data-categories/electronic-health-record-ehr-data
4. https://www.cms.gov/Medicare/E-Health/EHealthRecords
5. https://onlinecourses.nptel.ac.in/noc20_ee40

Term Work:

1. Term work should consist of 8 experiments and a Mini Project.
2. The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.
3. Total 25 Marks (Experiments: 10-Marks, Mini Project-10 Marks, Attendance Theory & Practical: 05-marks)

Oral & Practical exam

1. Based on the entire syllabus of **AI ML for Healthcare**

University of Mumbai

Syllabus

Honours/Minor Degree Program

In

Internet of Things

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023

University of Mumbai
Internet of Things
(With effect from 2022-23)

Year & Sem	Course Code and Course Title	Teaching Scheme Hours / Week			Examination Scheme and Marks					Credit Scheme
		Theory	Seminar/ Tutorial	Pract	Internal Assessment	End Sem Exam	Term Work	Oral/ Pract	Total	Credits
TE Sem V	**HIoTC501: IoT Sensor Technologies**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**--**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
TE Sem. VI	**HIoTC601: IoT System Design**	04	--	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
BE Sem. VII	**HIoTC701: Dynamic Paradigm in IoT**	04	--	--	20	80	--	--	100	04
	HIoTSBL701: Interfacing & Programming with IoTLab (SBL)	--	--	04	--	--	50	50	100	02
	Total	**04**	**-**	**04**	**100**		**50**	**50**	**200**	**06**
									Total Credits = 06	
BE Sem. VIII	**HIoTC801: Industrial IoT**	04	-	--	20	80	--	--	100	04
	Total	**04**	**-**	**-**	**100**		**-**	**-**	**100**	**04**
									Total Credits = 04	
Total Credits for Semesters V,VI, VII &VIII = 04+04+06+04=18										

Internet of Things: Sem V								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/ Oral**	**Tutorial**	**Total**
HIoTC501	**IoT Sensor Technologies**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg**					
HIoTC501	**IoT Sensor Technologies**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To provide in depth knowledge about the sensing mechanism.
2	To make students understand about the use of sensors in design of IoT based systems.
3	To familiarize students various types of sensors used to measure the physical quantities.
4	To develop reasonable level of competence in the design, construction and development of sensor suitable to the system requirements.
5	To Introduce students the current state of the art in sensor technology.
6	To familiarize students with electronics used to interface with sensors.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Understand the sensing mechanism and structural details of sensors.	L1, L2
2	Explain principles and working of the sensors.	L1,L2
3	Evaluate the performance of various types of sensors.	L5
4	Select the sensor suitable to system requirements.	L5
5	Interface the sensors with microcontrollers and Arduino	L6
6	Understand the current state of the art in sensor technology.	L2

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	1. Basics of Electrical and Electronics Engineering 2. Applied Mechanics 3. Applied Physics, Applied Chemistry	2	CO 1, CO2, CO3, CO4, CO5

I	**Sensor Fundamentals and Properties**	**Sensor Fundamentals and Properties:** Introduction to IoT, Need for sensors in IoT, Data Acquisition – sensor characteristics – electric charges, fields, potentials – capacitance – magnetism – inductance – resistance – piezoelectric – pyroelectric – Hall effect thermoelectric effects – sound waves – heat transfer – light – dynamic models of sensors. Need of actuators, all types of actuators and their working. Identification of sensor and actuator for real-time application **Self-learning Topics: IoT Systems, Transfer function and modelling of sensors**	**8**	CO1, CO2
II	**Optical, radiation and Displacement sensors**	**Optical, radiation and Displacement sensors** Photosensors: Photodiode, phototransistor and photo resistor, imaging sensors, UV detectors, Basic Characteristics of radiation sensors, Thermal infrared sensors, X-ray and Nuclear Radiation Sensors, Fibre Optic Sensors, Capacitive and Inductive Displacement Sensor, Electromagnetism and Inductance, Magnetic Field Sensors **Self-learning Topics: Optical sources and detectors, Sensors based on polymer optical fibers, Micro-structured and solid fibers**	**8**	CO1, CO2, CO3, CO4
III	**Presence, force, Pressure, Flow Sensors**	**Presence, force, Pressure, Flow Sensors** Potentiometric Sensors, Piezoresistive Sensors, Capacitive Sensors for presence, Inductive and Magnetic Sensors, Strain gages, Pressure sensitive films, piezoelectric force sensor, Piezoelectric Cables, Concept of Pressure, Mercury Pressure Sensor, Bellows, Membranes, and Thin Plates, Piezo resistive Sensors, Capacitive Sensors, VRP Sensors, Optoelectronic Pressure Sensors, Indirect Pressure Sensor, Vacuum Sensors, Basics of Flow Dynamics, Pressure Gradient Technique, Thermal Transport Sensors, Ultrasonic Sensors, Level Sensors **Self-learning Topics: Vibration energy harvesting with Piezoelectric, MEMS systems. Develop a sensor system for force measurement using piezoelectric transducer. Develop** Resistance Temperature Detector	**9**	CO1, CO2, CO3, CO4
IV	**Humidity, Moisture Chemical and Biological Sensors**	**Humidity, Moisture Chemical and Biological Sensors** Microphones: Characteristics, Resistive, condenser, Electret, Optical, Pizoelectric, Dynamic, Concept of humidity, Capacitive Humidity Sensors, Resistive Humidity Sensors, Thermal Conductivity Sensors, Optical Hygrometers, Oscillating Hygrometer, Soil Moisture Chemical Sensor Characteristics, Electrical and Electrochemical Sensors, Photoionization Detectors, Physical	**8**	CO1, CO2, CO3, CO4, CO5

		Transducers, Spectrometers, Thermal Sensors, Optical Transducers, Multi-sensor Arrays Artificial Microsystems for Sensing Airflow, Temperature, and Humidity by Combining MEMS and CMOS Technologies **Self-learning Topics: Biosensors for biomedical applications**		
V	**Interface Electronic Circuits**	**Interface Electronic Circuits** Introduction, Signal Conditioners, Sensor Connections, Excitation Circuits, Analog to Digital Converters, Integrated Interfaces, Data Transmission, Noise in Sensors and Circuits, Batteries for Low-Power Sensors, Types of Single board computers, various sensor interfacing with Arduino, Embedded C Programming. data communication protocol interfacing, study the properties of LDR, Build a simple LED light intensity controller, Linux on Raspberry Pi, Interfaces, and Programming. **Self-learning Topics: Python Programming to interface sensors**	**8**	CO1, CO2, CO5
VI	**Current Trends in sensors and Technology**	**Current Trends in sensors and Technology** Smart Sensors: Introduction, Primary sensors, Excitation, Amplification, Filters, Converters, Compensation, Information Coding/Processing, Data Communication, Standards for Smart Sensor Interface, The Automation Sensor Technologies: Introduction, Film Sensors, Thick Film Sensors, Thin Film Sensors, Semiconductor IC Technology—Standard Methods, Microelectromechanical Systems (MEMS), Nano-sensors Sensor Applications: Onboard Automobile sensors, Home appliances sensors, Aerospace Sensors, Sensors for Environmental Monitoring **Self-learning Topics: Energy Harvesting, Self-powered Wireless Sensing in ground, Ground penetrating sensors**	**9**	CO1, CO2, CO3, CO4, CO5, CO6

Text Books:

1. Jacob Fraden, “Hand Book of Modern Sensors: physics, Designs and Applications”, 2015, 3rd edition, Springer, New York.
2. Jon. S. Wilson, “Sensor Technology Hand Book”, 2011, 1st edition, Elsevier, Netherland
3. D. Patranabis – Sensor and Transducers (2e) Prentice Hall, New Delhi, 2003
4. Vijay Madisetti and Arshdeep Bahga, “Internet of Things (A Hands-on-Approach)”,1st Edition, VPT, 2014

References:

1. Edited by Qusay F Hasan, Atta ur rehman Khan, Sajid A madani, “Internet of Things Challenges, Advances, and Application”, CRC Press
2. Triethy HL - Transducers in Electronic and Mechanical Designs, Mercel Dekker, 2003
3. Gerd Keiser,”Optical Fiber Communications”, 2017, 5th edition, McGraw-Hill Science, Delhi.

4. John G Webster, Halit Eren, “Measurement, Instrumentation and sensor Handbook”, 2014, 2nd edition, CRC Press, Taylor and Fransis Group, New York.
5. Adrian McEwen, “Designing the Internet of Things”, Wiley Publishers, 2013, ISBN: 978-1-118-43062-0
6. Nathan Ida, “Sensors, Actuators and their Interfaces: A Multidisciplinary Introduction”, Second Edition, IET Control, Robotics and Sensors Series 127, 2020

Online References:

Sr. No.	Website Name
3.	https://nptel.ac.in/courses/108/108/108108123/
4.	https://nptel.ac.in/courses/108/108/108108098/
3.	https://nptel.ac.in/noc/courses/noc19/SEM2/noc19-ee41/
4.	https://nptel.ac.in/courses/108/106/108106165/

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Internet of Things: Sem VI								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/ Oral**	**Tutorial**	**Total**
HIoTC601	**IoT System Design**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg.**					
HIoTC601	**IoT System Design**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To learn basic principles, concepts, and technologies for internet of things.
2	To understand various architectures of IOT.
3	To train the students to build IoT systems using sensors, single board computers and open source IoT platform for given application.
4	To learn and implement various networking and communication protocols.
5	To design and analyze IoT for given applications.
6	To Evaluate performance of given IoT system.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Able to explain principles, concepts, and technologies for internet of things.	L1, L2
2	Able to identify various building blocks of IoT system	L1,L2
3	Able to analyze and evaluate various networking and communication protocols used in IoT system	L3,L4
4	Able to select appropriate interface for given application	L3
5	Able to design and analyze IoT system for given application	L4,L5
6	Able to evaluate performance of given IOT System	L5

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	Comment (Prerequisite syllabus should not be considered for paper setting) Basics of Embedded System, IoT Sensors, Digital design	**2**	--

I	**Overview of IoT System**	What is IoT System? IoT Impact, Current Trends in IoT, IoT Challenges, Comparing IoT Architectures, A Simplified IoT Architecture, The Core IoT Functional Stack How are IoT Systems different from traditional system Values and Uses of IoT Functional View and Infrastructure view of IoT Systems **Self-learning Topics:** *Understanding the Issues and Challenges of a More Connected World*	**6**	CO1, CO2
II	**Networking Protocols**	OSI Model for the IoT/M2M System Lightweight M2M Communication Protocols, Internet based Communications, IP addressing in IoT, Network Model, TCP & UDP, Client-Server architecture **Self-learning Topics:** *How to choose correct protocol for our network.*	**8**	CO3
III	**Communication Protocols**	IoT Edge to Cloud protocols: HTTP, REST APIs, WebSocket, MQTT, COAP, Comparison of Protocols.M2M Communication Protocols, Bluetooth BR/EDR and Bluetooth low energy. RFID IoT System , RFID IoT Network Architecture, ZigBee IP/ZigBee SE2.0, Wifi(WLAN), Message Communication protocols for connected devices Data exchange formats: JSON & XML, Node-Red, Flow control using Node-Red, learning the different nodes of Node-RED for implementing the Communication Protocols **Self-learning Topics:** *Types of Communication*	**10**	CO3,CO4
IV	**Sensor Interfaces**	Digital Interfaces: UART, Serial Peripheral Interface (SPI), I2C (Inter-Integrated Circuit), Controller Area Network (CAN), Middleware Technologies, Communication Protocols and Models. Practical Components Programming with interface in Arduino, MBed and Raspberry Pi **Self-learning Topics:** *SMART SENSOR INTERFACES*	**10**	CO4
V	**Design principles for prototyping**	Design solution for ubiquitionos and utility, Interface design for user experience, Designing for data privacy, Interfacing – Apps & Webs, Designing for Affordability, Cost v/s Ease of Prototyping, Prototypes and Production, Selection of embedded platform, Prototype and Mass personalization, Open Source v/s Closed Source ,Amplification and Signal Conditioning- Integrated Signal Conditioning- Digital conversion- MCU Control MCUs for Sensor Interface- Techniques and System Considerations- Sensor Integration **Self-learning Topics:** *Principles for Prototyping and moving towards Product Development*	**8**	CO5
VI	**IoT, case studies**	Arduino Programming for Ethernet and Wifi connectivity, Networking and Data logging with Raspberry Pi Applications-Agriculture, Medical, Fire detection, Air pollution prediction, Earthquake early detection; for smart environmental care, smart traveling, Home Automation **Self-learning Topics**: *IoT enabled Business solution in Supply Chain*	**8**	CO6

Text Books:

1. S. Misra, A. Mukherjee, and A. Roy, 2020. Introduction to IoT. Cambridge University Press.

2. Adrian McEwen and Hakim Cassimally, —Designing the Internet of Things‖, John Wiley and Sons Ltd, UK, 2014.

3. Milan Milenkovic, Internet of Things: Concepts and System Design, Springer International Publishing,May 2020cation

4. Dr.Raj Kamal,Internet of Things(IoT) , Architecture and Design Principles.McGraw Hill Education.

References:

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry,"IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things
2. N. Ida, Sensors, Actuators and Their Interfaces, Scitech Publishers, 2014.
3. Editors OvidiuVermesan Peter Friess,'Internet of Things – From Research and Innovation to Market
4. Dr. Guillaume Girardin , Antoine Bonnabel, Dr. Eric Mounier, 'Technologies Sensors for the Internet of Things Businesses & Market Trends 2014 -2024',Yole Development Copyrights ,2014

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

- **Question paper format**

  - Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
  - **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
  - A total of **four questions** need to be answered

Internet of Things: Sem VII								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/ Oral**	**Tutorial**	**Total**
HIoTC701	**Dynamic Paradigm in IoT**	**03**	**--**	**--**	**03**	**--**	**--**	**03**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg. of 2 Tests**					
HIoTC701	**Dynamic Paradigm in IoT**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To explore the role of the cloud in Internet of Things deployment.
2	To introduce the usage of different machine learning algorithms on IoT Data.
3	To explore data analytics and data visualization on IoT Data.
4	To explore the role of Fog computing in Internet of Things.
5	To explore design issues and working principles of various security measures and various standards for secure communication in IoT.
6	To develop the ability to integrate IoT with Dev-ops.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Identify the need for the cloud in IoT deployment and describe different Cloud provider's architecture.	L1,L2
2	Use and correlate machine learning techniques on IoT Data.	L3,L4
3	Apply IoT analytics and data visualization.	L3
4	Recognize the use of Fog Computing in the Internet of things.	L1,L2
5	Explain the need of security measures in the Internet of Things.	L4
6	Apply the knowledge of Dev-ops in IoT applications.	L3

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	Basics of Cloud Computing, Basics of Machine learning and primitives of cryptography	**2**	--

I	**IoT and CLOUD**	**Cloud Computing Concept, Grid/SOA and Cloud Computing, Cloud Middleware** **NIST's SPI Architecture and Cloud Standards, The Cloud of Things--** The Internet of Things and Cloud Computing **The Cloud of Things Architecture**-- Four Deployment Models, Vertical Applications, Fifteen Essential Features, Four Technological Pillars, Three Layers of IoT Systems, Foundational Technological Enabler **Cloud Providers and Systems** -- Microsoft Azure IoT, Amazon Web Services, Google's cloud IoTs. **Self-learning Module:** IBM Watson Cloud	**10**	CO1
II	**IoT and Machine Learning**	**Advantages of IoT and Machine Learning Integration,** I**mplementation of Supervised Algorithm-** Regression (Linear and Logistic), SVM for IoT-Neural Network **on case study:** Agriculture and IoT, Smart Home etc. **Self-Learning Module:** Regression, SVM	**6**	CO2
III	**IoT and Data Analytics**	**Defining IoT Analytics, IoT Analytics challenges, IoT analytics for the cloud**-Microsoft Azure overview– Strategies to organize Data for IoT Analytics, Linked Analytics Data Sets, Managing Data lakes, The data retention strategy. **Communicating with Others- Visualization and Dash boarding-** Designing visual analysis for IoT data, creating a dashboard –creating and visualizing alerts. **Self-learning Topics:** Study real time case study on IoT Analytics.	**8**	CO3
IV	**IoT and Fog Computing**	**Fog computing Basics, The Hadoop philosophy for Fog computing, Fog Computing versus Edge Computing versus cloud computing, Open Fog Reference Architecture Application services**-- Application support, Node management and software backplane, Hardware virtualization, Open Fog node security, Network Accelerators Compute, Storage Hardware platform infrastructure, Protocol abstraction, Sensors, actuators, and control systems, Fog Topology. **Self-learning Module:** Amazon Green grass and Lambda (implementation)	**8**	CO4
V	**IoT and it's Security**	Cyber security vernacular Attack and threat terms, Defense terms, Anatomy of IoT cyber attacks – Mirai, Stuxnet, Chain Reaction, Physical and hardware security, Root of Trust, Key management and trusted platform modules, Processor and memory space, Storage security, Network stack – Transport Layer Security, Software defined perimeter, Software-Defined Perimeter architecture, **Self-learning Module:** OWASP-Existing Security attacks and its prevention methods.	**8**	CO5
VI	**IoT and Devops**	Introduction to DevOps, DevOps application - business scenarios, DevOps process -- Source Code Management (SCM), Code review, Configuration Management, Build management, Artifacts repository management, Release management, Test automation, Continuous integration, Continuous delivery, Continuous deployment, Infrastructure as Code, Routine automation, Key application performance monitoring/indicators. DevOps frameworks--DevOps maturity life cycle, DevOps maturity map, DevOps progression	**10**	CO6

		framework/readiness model, DevOps maturity checklists, Agile framework for DevOps process projects, Agile ways of development **Tool for IoT—**Chef and Puppet, Setting up Chef and Puppet, Multi-tier Application Deployment, NETCONF-YANG Case Studies- Steps for IoT device management with NETCONF-YANG, Managing Smart irrigation IoT system with NETCONF-YANG, Managing Home Intrusion Detection IoT system with NETCONF-YANG **Self-learning Topics:** Compare different tool of IoT.		

Text Books:

1. The Internet of Things in the Cloud A Middleware Perspective, Honbo Zhou – CRC Publication.
2. Analytics for the Internet of Things (IoT), Andrew Minteer, Packt Publication 2017
3. Internet of Things- Hands on Approach, Arshdeep Bagha, Vijay Medisetti, Published by Arshdeep Bagha and Vijay Medisetti,2014.
4. Hands-on DevOps, Sricharan Vadapalli, Packt Publication, 2017
5. Internet of things For Architects, Perry Lea Packt Publication,2018

References:

1. Enterprise Cloud Computing, Gautam Shroff, Cambridge,2010
2. Mastering Cloud Computing -Foundations and Applications Programming, Raj Kumar Buyya, Christian Vecchiola, S. Thamarai Selvi, MK Publication, 2013.
3. Machine Learning in Action‖, Peter Harrington, DreamTech Press
4. Introduction to Machine Learning‖, Ethem Alpaydın, MIT Press
5. Learning AWS IoT- Effectively Manage Connected Devices on the AWS Cloud Using Services Such as AWS Greengrass, AWS Button, Predictive Analytics and Machine Learning, Agus Kurniawan, Packt Publication,2018
6. Practical Dev-Ops, Joakim Verona, Packt Publication, 2016

Online References:

Sr. No.	Website Name
1.	https://hub.packtpub.com/25-datasets-deep-learning-iot/
2.	https://data.world/datasets/iot
3.	https://dashboard.healthit.gov/datadashboard/data.php
4.	https://www.data.gov/
5.	https://dev.socrata.com/data/
6.	https://www.kaggle.com/

Assessment:

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➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

Internet of Things: Sem VII								
		Teaching Scheme (Contact Hours)			Credits Assigned			
Course Code	Course Title	Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
HIoTSBL701	Interfacing & Programming with IoT Lab (SBL)	--	4	--	--	2	--	02

Course Code	Course Title	Examination Scheme						
		Theory Marks				Term Work	Oral	Total
		Internal assessment			End Sem. Exam			
		Test1	Test 2	Avg. of 2 Tests				
HIoTSBL701	Interfacing & Programming with IoT Lab (SBL)	--	--	--	--	50	50	100

Lab Objectives:

Sr. No.	Lab Objectives
The Lab aims:	
1	To Understand the definition and significance of the Internet of Things.
2	To Discuss the architecture, operation, and business benefits of an IoT solution.
3	To Examine the potential business opportunities that IoT can uncover.
4	To Explore the relationship between IoT, cloud computing, and DevOps.
5	To Identify how IoT differs from traditional data collection systems.
6	To Explore the interconnection and integration of the physical world and able to design & develop IOT Devices.

Lab Outcomes:

Sr. No.	Lab Outcomes	Cognitive levels of attainment as per Bloom's Taxonomy
On successful completion, of lab, learner/student will be able to:		
1	Adapt different techniques for data acquisition using various IoT sensors for different applications.	L6
2	Demonstrate the working of actuators based on the collected data.	L2
3	Use different IoT simulators and correlate working of IoT protocols.	L3
4	Adapt different techniques for Integrating IoT services to other third-party Clouds.	L6
5	Execute DevOps methodologies for continuous integration and continuous deployment of IoT application.	L3
6	Implement IoT protocols like MQTT for communication to realize the revolution of internet in mobile devices, cloud and sensor networks.	L3

Prerequisite:

IoT introduction course: Basics of IoT, Introduction to Embedded systems

Hardware & Software Requirements:

Hardware Requirements	Software Requirements	Other Requirements
PC With Following Configuration 1. Intel PIV Processor 2. 4 GB RAM 3. 500 GB Harddisk 4. Network interface card 5. Sensors 6. IoT Kit (Arduino/ARM/Raspberry Pi)	1. Windows or Linux Desktop OS 2. DeVops 3.Python 4. IoT Simulator/Emulator (open source)	1. Internet Connection for installing additional packages if required

This lab will describe the market around the Internet of Things (IoT), the technology used to build these kinds of devices, how they communicate, how they store data, and the kinds of distributed systems needed to support them. Divided into four main modules, we will learn by doing. We will start with simple examples and integrate the techniques we learn into a class project in which we design and build an actual IoT system. The client will run in an emulated ARM environment, communicating using common IoT protocols with a cloud enabled backend system with DevOps integration.

Suggested List of Experiments

Sr. No.	Detailed Content	Hours	LO Mapping
1	To study and implement interfacing of different IoT sensors with Raspberry Pi/Arduino/ModeMCU	**4**	LO1
2	To study and implement interfacing of actuators based on the data collected using IoT sensors. (like led switch ON/OFF, stepper word)	**4**	LO2
3	To study and demonstrate Contiki OS for RPL (like Create 2 border router and 10 REST clients, Access border router from other network (Simulator))	**4**	LO3
4	To study and demonstrate use of IoT simulators (like Beviswise) on any real time device (LED/stepper motor)	**4**	LO3
5	Select any one case study (in a group of 2-3) and perform the experiments 5 to 10. The sample case studies can be as follows: 1. Smart home automation system 2. Healthcare management system 3. Smart traffic management system & so on… Write a program on Raspberry Pi to push and retrieve the data from cloud like thingspeak, thingsboard, AWS, Azure etc.	**8**	LO4
6	To install MySQL database on Raspberry Pi and perform basic SQL queries for analysis data collected.	**6**	LO4
7	To study and implement IoT Data processing using Pandas.	**4**	LO4

8	To study and implement Continuous Integration using Jenkins on IoT data and also perform interfacing of Raspberry Pi into Jenkins.	**6**	LO6
9	To study and implement Continuous Deployment (Infrastructure as a code) for IoT using Ansible.	**6**	LO6
10	To study MQTT Mosquitto server and write a program on Arduino/Raspberry Pi to publish sensor data to MQTT broker.	**6**	LO5

Books / References:

1. Jake VanderPlas,“ Python Data Science Handbook”, O’Reilly publication,2016
2. Joakim Verona,” Practical DevOps”, PACKT publishing, 2016
3.Honbo Zhou,” The internet of things in the cloud”, CRC press, Taylor and Francis group, 2012
4. Perry Lea,” Internet of things for architects”, PACKT publishing, 2018

Online Resources:

Sr. No.	Website Name
1.	https://spoken-tutorial.org/watch/Arduino/Introduction+to+Arduino/English/
2.	https://pythonprogramming.net/introduction-raspberry-pi-tutorials/
3.	https://iotbytes.wordpress.com/basic-iot-actuators/
4.	http://www.contiki-os.org/
5.	https://www.bevywise.com/iot-simulator/
6.	https://mqtt.org/

Term Work:

The Term work shall consist of at least 10 practical based on the above list. The term work Journal must include at least 2 assignments. The assignments should be based on real world applications which cover concepts from all above list**.**

Term Work Marks: 50 Marks (Total marks) = 40 Marks (Experiment) + 5 Marks (Assignments/tutorial/write up) + 5 Marks (Attendance)

Oral Exam: An Oral exam will be held based on the above syllabus.

Internet of Things: Sem VIII								
Course Code	**Course Title**	**Theory**	**Practical**	**Tutorial**	**Theory**	**Practical/Oral**	**Tutorial**	**Total**
HIoTC801	**Industrial IoT**	**04**	**--**	**--**	**04**	**--**	**--**	**04**

Course Code	**Course Title**	**Examination Scheme**							
		Theory Marks				**Term Work**	**Practical**	**Oral**	**Total**
		Internal assessment			**End Sem. Exam**				
		Test1	**Test 2**	**Avg. of 2 Tests**					
HIoTC801	**Industrial IoT**	**20**	**20**	**20**	**80**	**--**	**--**	**--**	**100**

Course Objectives:

Sr. No.	**Course Objectives**
The course aims:	
1	To learn the concepts of Industry 4.0 and IIOT.
2	To learn reference Architecture of IIOT.
3	To learn Industrial Data Transmission and Industrial Data Acquisition.
4	To learn middleware and WAN technologies.
5	To learn IIOT Block chain and Security.
6	To learn different applications and securities in IIOT.

Course Outcomes:

Sr. No.	**Course Outcomes**	**Cognitive levels of attainment as per Bloom's Taxonomy**
On successful completion, of course, learner/student will be able to:		
1	Understand the concepts of Industry 4.0 and IIOT.	L1,L2
2	Understand reference Architecture of IIOT.	L1,L2
3	Understand Industrial Data Transmission and Industrial Data Acquisition.	L1,L2
4	Understand middleware and WAN technologies in IIOT.	L1,L2
5	Understand the concepts of Blockchain and Security in IIOT.	L1,L2
6	Apply security in IIOT applications.	L3

DETAILED SYLLABUS:

Sr. No.	**Module**	**Detailed Content**	**Hours**	**CO Mapping**
0	**Prerequisite**	IOT Concepts, Sensor Technology, IOT Stack and Protocols, Design IoT systems, WSN etc.	**02**	--

I	**Introduction**	Overview of Industry 4.0 and Industrial Internet of Things, Industry 4.0: Industrial Revolution: Phases of Development, Evolution of Industry 4.0, Environment impacts of industrial revolution, Industrial Internet, Basics of CPS, CPS and IIOT, Design requirements of Industry 4.0, Drivers of Industry 4.0, Sustainability Assessment of Industries, Smart Business Perspective, Cyber security, Impacts of Industry 4.0, Industrial Internet of Things: Basics, IIOT and Industry 4.0, Industrial Internet Systems, Industrial Sensing, Industrial Processes, IIOT Challenges – Identifying Things within the internet, Discovering Things and the Data they possess, Managing massive amount of data, Navigating Connectivity Outages, IIOT Edge - Leveraging the Power of Cloud Computing, Communicating with Devices on the Edge, Determining a Request/Response Model **Self-learning Topics:** Study real time IIoT challenges in industry.	**06**	CO1
II	**IIOT Reference Architecture**	The IIC Industrial Internet Reference Architecture - Industrial Internet Architecture Framework (IIAF),Industrial Internet Viewpoints -Functional, Operational, Information Application and Business Domain of IIAF. The Three-Tier Topology, Key Functional Characteristics of Connectivity. Software Architectural Style for the Industrial Internet of Things - Software Architecture Practice, Advanced Architectural Styles, Systems of Systems, Challenges of Software Engineering in IIoT, Principles for Software Architecture design in IIoT, The Principled Decomposition, The Architectural Style **Self-learning Topics:** Study IIoT Architecture.	**08**	CO2
III	**Industrial Data Transmission and Industrial Data Acquisition**	Introduction, (Features and Components of - Foundation Fieldbus, Profibus, HART,Interbus, Bitbus, CC-Link, Modbus, Batibus, DigitalSTROM, Controller Area Network, DeviceNet, LonWorks, ISA 100.11a, Wireless HART, LoRa and LoRaWAN) NB-IoT, IEEE 802.11AH, Distributed Control System, PLC, SCADA **Self-learning Topics:** Study SCADA, PLC in detail.	**10**	CO3
IV	**IIOT Middleware and WAN Technologies**	(From Industrial Application Perspective) Examining Middleware Transport Protocols (TCP/IP, UDP, RTP, CoAP), Middleware Software Patterns (Publish Subscribe Pattern, Delay Tolerant Networks), Software Design Concepts – Application Programming Interface – A Technical Perspective, Why Are APIs Important for Business? Web Services, IIOT Middleware Platforms – Middleware Architecture	**10**	CO4

		IIOT WAN Technologies and Protocols - IIoT Device Low-Power WAN Optimized Technologies for M2M, SigFox,LoRaWAN,nWave, Dash7 Protocol, Ingénue RPMA, Low Power Wi-Fi, LTE Category-M, Weightless, Millimeter Radio **Self-learning Topics:** Study different IIoT Middleware and WAN Technologies.		
V	**IIOT Blockchain and Security**	Blockchains and cryptocurrencies in IoT, Bitcoin (blockchain-based), IOTA- distributed ledger (directed a cyclical graph-based), Government regulations and intervention, US Congressional Bill – Internet of Things (IoT) Cyber security Improvement Act of 2017, Other governmental bodies, IoT security best practices, Holistic security. **Self-learning Topics:** Case study on IIoT Block chain and Security.	**08**	CO5
VI	**IIOT Applications and Securities**	The IoT Security Lifecycle- The secure IoT system implementation lifecycle, Implementation and integration, IoT security CONOPS document, Network and security integration, System security verification and validation (V&V), Security training, Secure configurations, Operations and maintenance, Managing identities, roles, and attributes, Security monitoring, Penetration testing, Compliance monitoring, Asset and configuration management, Incident management, Forensics, Dispose, Secure device disposal and zeroization, Data purging, Inventory control, Data archiving and records management Securing the Industrial Internet - Security in Manufacturing, PLCs and DCS, Securing the OT (Operation Technology), Network, System Level: Potential Security Issues, Identity Access Management Develop New Business Models – Adopt Smart Architectures and Technologies, Sensor-Driven Computing, Industrial Analytics, Intelligent Machine Applications, Transform the Workforce Case Studies – Healthcare Applications in Industries – Challenges associated with Healthcare, Introduction, Smart Devices, Advanced technologies used in Healthcare. Inventory Management and Quality Control – Introduction, Inventory Management and IIOT, Quality Control Manufacturing Industry, Automotive Industry and Mining Industry **Self-learning Topics:** Study real time IIoT application.	**08**	CO6

Text Books:

1. "Industry 4.0: The Industrial Internet of Things", by Alasdair Gilchrist (Apress)
2. "Introduction to Industrial Internet of Things and Industry 4.0",by Sudip Misra, Chandana Roy And Anandarup Mukherjee, CRC Press (Taylor & Francis Group)
3. "Internet **of Things** Principles and Paradigms", by Rajkumar Buyya, Amir Vahid Dastjerdi, ELSEVIER Inc.
4. Internet of things For Architects, Perry Lea Packt Publication,2018

References:

1. "Practical Internet of Things Security", by Brian Russell, Drew Van Duren (Packt Publishing)
2. "Industrial Internet of Things and Communications at the Edge", by Tony Paine, CEO, Kepware Technologies
3. "Architectural Design Principles For Industrial Internet of Things", Hasan Derhamy, Luleå University of Technology, Graphic Production

Online References:

Sr. No.	Website Name
1.	https://onlinecourses.nptel.ac.in/noc20_cs69/preview
2.	https://www.coursera.org/specializations/developing-industrial-iot
3.	https://www.coursera.org/lecture/advanced-manufacturing-enterprise/the-industrial-internet-of-things-iiot-59EvI
4.	https://www.coursera.org/lecture/industrial-iot-markets-security/segment-12-blockchains-l4aG9

Assessment:

Internal Assessment (IA) for 20 marks:

- IA will consist of Two Compulsory Internal Assessment Tests. Approximately 40% to 50% of syllabus content must be covered in First IA Test and remaining 40% to 50% of syllabus content must be covered in Second IA Test

➢ **Question paper format**

- Question Paper will comprise of a total of **six questions each carrying 20 marks Q.1** will be **compulsory** and should **cover maximum contents of the syllabus**
- **Remaining questions** will be **mixed in nature** (part (a) and part (b) of each question must be from different modules. For example, if Q.2 has part (a) from Module 3 then part (b) must be from any other Module randomly selected from all the modules)
- A total of **four questions** need to be answered

University of Mumbai

Syllabus

Honours/Minor Degree Program

In

Waste Technology

FACULTY OF SCIENCE & TECHNOLOGY

(As per AICTE guidelines with effect from the academic year 2022-2023)

University of Mumbai Waste Technology (With effect from 2022-23)										
Year and Sem	**Course Code and Course Title**	**Teaching Scheme Hours/ Week**			**Examination Scheme and Marks**					**Credit Scheme**
		Theory	**Seminar/ Tutorial.**	**Pract.**	**Internal Assessment**	**End Sem Exam**	**Term Work**	**Oral**	**Total**	**Credits**
TE Sem V	**HCWC501: Solid And Hazardous Waste Management**	4	–	–	20	80	–	–	100	4
	Total	**4**	**–**	**–**	**100**		**–**	**–**	**100**	**4**
										Total Credits=04
TE Sem VI	**HCWC601: Liquid Effluent Management**	4	–	–	20	80	–	–	100	4
	Total	**4**	**–**	**–**	**100**		**–**	**–**	**100**	**4**
										Total Credits=04
BE Sem VII	**HCWC701: Waste Volorization I**	4	–	–	20	80	–	–	100	4
	HCWSBL701: Waste Technology .Skill Based Lab -1	–	–	2	–	–	50	50	100	2
	Total	**4**	**–**	**2**	**100**		**50**	**50**	**200**	**6**
										Total Credits=06
BE Sem VIII	**HCWC801: Sustainable Waste Volorization II**	4	–	–	20	80	–	–	100	4
	Total	**4**	**–**	**–**	**100**		**–**	**–**	**100**	**4**
										Total Credits=04
Total Credit for Semester V+VI+VII+VIII=18										

Waste Technology: Semester V		
Course Code	**Course Name**	**Credits**
HCWC501	**SOLID AND HAZARDOUS WASTE MANAGEMENT**	**04**

Course Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**		**Tutorial**	**Total**
04	**-**	**-**	**04**	**-**	**-**	**04**

Theory					Term Work / Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs**	**--**		**--**	**100**

Course Objectives:

1. To recognize the relevant, regulations that apply for facilities used for disposal and destruction of waste.
2. To provide in depth knowledge of municipal solid waste management
3. To provide in-depth knowledge of hazardous waste management
4. To provide in-depth knowledge of Physico-chemical processes useful for the treatment of municipal and solid wastes
5. To provide in-depth knowledge of biological processes useful for the treatment of municipal and solid wastes.
6. Know the necessity of environment risk assessment.

Module	Content	Hours
1	**Rules and Regulations** Municipal solid waste (management and handling) rules, hazardous waste (management and handling) rules, biomedical waste handling rules, fly ash rules, recycled plastics usage rules, batteries (management and handling) rules	4
2	**Municipal Solid Waste Management** Need for management, sources, composition, generation rates, collection of waste, separation, transfer and transport of waste, treatment and disposal options, source reduction of wastes, recycling and reuse.	9
3	**Hazardous Waste Management** Need for management, hazardous characterization of waste, compatibility and flammability of chemicals, waste sampling, TCLP tests, fate and transport of chemicals, health effects	9
4	**Physicochemical Treatment of Solid and Hazardous Waste** Chemical treatment processes for MSW (combustion, stabilization and solidification of hazardous wastes), physicochemical processes for hazardous wastes (soil vapour extraction, air stripping, chemical oxidation), ground water contamination and remediation	9

5	**Biological Treatment of Solid and Hazardous Waste** Composting, bioreactors, anaerobic decomposition of solid waste, principles of biodegradation of toxic waste, inhibition, co-metabolism, oxidative and reductive processes, slurry phase bioreactor, in-situ remediation. Landfill design for solid and hazardous wastes, leachate collection and removal, landfill covers, incineration	14
6	**Environmental Risk Assessment** Defining risk and environmental risk, methods of risk assessment, case studies	7

Course Outcome:

On completion of the course the students will:

1 understand rules and regulations for handling solid waste.
2 understand principals of municipal solid waste management.
3 understand hazardous waste management.
4 learn physicochemical treatment of solid and hazardous waste.
5 understand biological treatment of solid and hazardous waste.
6 understand environment risk assessment.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.**

First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lectures.
2. Question paper will comprise of total **six questions, each carrying 20 marks.**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
5. Only **Four questions need to be solved.**

Test Books/Reference Books:

1 Tchobanoglous G., Theisen H. and Vigil S.A., "Integrated Solid Waste Management", McGraw-Hill International editions.
2 Bhide A.D. and Sundaresan B.B., "Solid Waste Management, Collection, Processing and Disposal", Nagpur.
3 "Manual on Municipal Solid Waste Management", CPHEEO, Ministry of Urban Development, Government of India.
4 Management and Handling Rules for: municipal solid waste, biomedical waste, hazardous waste and radioactive wastes, Government of India Publications.
5 Solid Waste Management Hand Book – Pavoni

Waste Technology: Semester VI		
Course Code	**Course Name**	**Credits**
HCWC601	**LIQUID EFFLUENT MANAGEMENT**	**04**

Course Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**		**Tutorial**	**Total**
04	**-**	**-**	**04**	**-**	**-**	**04**

Theory					Term Work / Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs**	**--**		**--**	**100**

Course Objectives:

1 To learn how to minimize waste and study available treatment options.
2 To know concept of pollution control.
3 To learn ion exchange process and various adsorption techniques.
4 To study advanced methods for effluent management.
5 To know methods of waste reduction and how to recover byproducts.
6 To learn concepts and design of natural treatment system.

Module	Contents	Hours
1	**Waste Minimization and Treatment options** Methods of waste volume and strength reductions, Waste minimization - 4 R concepts, Waste audit, Classification of treatment and development of treatment flow sheets.	9
2	**Pollution control** Zero discharge concept. Concept of common effluent treatment plant- objectives, types of CETP, technical and financial aspects. Rural wastewater systems – septic tanks, two-pit latrines, ecotoilet, soak pits.	8
3	**Ion Exchange and Adsorption** Ion exchange process, ion exchange resins, exchange capacity, ion exchange, chemistry and reactions, Design of ion exchange units, Disposal of concentrate waste streams. Types of adsorption, adsorption isotherms, activated carbon adsorption kinetics, analysis and design of adsorption column.	9
4	**Advanced methods for effluent management** Ozonation, photocatalysis, wet air oxidation, evaporation, reverse osmosis, biological treatment for toxic waste	9
5	**Waste Reduction/Byproduct recovery** Waste reduction/ byproduct recovery for sugar, paper mill, petroleum and oil refineries, steel and engineering industries, fertilizer and pesticide industries, organic & inorganic manufacturing industries	9

6	**Natural Treatment Systems** Constructed wetland and aquatic treatment systems; Types- free water surface and subsurface constructed wetlands, selection of plants, removal mechanisms, applications, design procedure for constructed wetlands, management of constructed wetlands	8

Course Outcomes:

1 Understand minimizing the waste and available treatment options.
2 Understand concept of pollution control.
3 Understand ion exchange process/design and adsorption techniques.
4 Advanced methods for effluent management.
5 Waste reduction/byproducts recovery for manufacturing industries.
6 Concepts and design of natural treatment system.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lectures.
2. Question paper will comprise of total **six questions, each carrying 20 marks.**
3. **Question 1** will be compulsory and should cover **maximum contents of the curriculum.**
4. **Remaining questions will be mixed in nature** (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
5. Only **Four questions need to be solved.**

Text Books and References:

1 Eckenfelder, W.W., Industrial Water Pollution Control, McGraw-Hill, 1999.
2 Arceivala, S.J., Wastewater Treatment for Pollution Control, McGraw-Hill, 1998.
3 Frank Woodard, Industrial waste treatment Handbook, Butterworth Heinemann, New Delhi, 2001

Waste Technology: Semester VII		
Course Code	**Course Name**	**Credits**
HCWC701	**WASTE VALORIZATION I**	**04**

Course Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**		**Tutorial**	**Total**
04	**-**	**-**	**04**	**-**	**-**	**04**

Theory					Term Work / Practical/Oral			Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	PR	OR	
Test-I	Test-II	Average						
20	**20**	**20**	**80**	**03 Hrs**	**--**		**--**	**100**

Course Outcomes:

1. To know waste valorization process used for reduce, reuse and recycle.
2. To learn biovalorization of industrial waste.
3. To know concept of biorefineries and related factors.
4. To learn recent trends and vermiculture.
5. To know biovalorisation of agriculture biomass.
6. To study case studies based on waste recycling.

Module	Contents	Hours
1	**Wastes valorization processes:** Preparation for reuse, recycling, and other valorisation processes. Analysis of advantages and limitations.	5
2	**Bio-valorisation of industrial wastes:** Anaerobic bio-valorisation of leather industry solid waste and production of high value-added biomolecules and biofuels, Anaerobic bio-valorisation of pulp and paper mill waste, Bio-valorisation of winery industry waste to produce value-added products, Conversion of textile effluent wastewater into fertilizer using marine cyanobacteria along with different agricultural waste.	12
3	**Biorefineries:** Biorefinery for hydrocarbons and emerging contaminants, Biodesulfurization of petroleum wastes, Microbial leaching of heavy metals from e- waste, opportunities and challenges.	8
4	**Biovalorisation of agricultural biomass:** Recent trends in biorefinery-based valorisation of lignocellulosic biomass, Protein engineering approaches for lignocellulosic ethanol biorefinery, Biovalorization potential of agro forestry/industry biomass for optically pure lactic acid fermentation, Opportunities and challenges, Agro-based sugarcane industry wastes for production of high-value bioproducts	11
5	**Recent trends and vermiculture** Recent trends and challenges in bioleaching technologies, membrane separation technologies for downstream processing. Definition, scope and importance – common species for culture	8

	– environmental requirements – culture methods- applications of vermiculture-Potentials and constraints for composting in India-large scale and decentralized plants.	
6	**Case studies on waste recycling** Recycling technologies for paper, glass, metal, plastic, used lead acid battery, end of life vehicle recycling, electronic waste recycling, waste oil, recycling solvent recovery, drivers and barriers for material recycling, social, legal and economic factors, environmental impacts of waste recycling, design for the environment the life cycle approach.	8

Course Outcomes:

On completion of this course students will

1 understand the waste valorization process to reduce, reuse and recycle.
2 understand Biovalorization of industrial waste
3 understand concept of biorefineries, their opportunities and challenges
4 understand recent trends and vermiculture.
5 understand biovalorisation of agriculture biomass.
6 understand waste recycling using case studies.

Assessment

Internal Assessment (20 Marks):

Consisting **Two Compulsory Class Tests.** First test based on approximately 40% of contents and second test based on remaining contents (approximately 40% but excluding contents covered in Test I).

End Semester Examination (80 marks):

1. Weightage of each module in end semester examination will be proportional to number of respective lectures.
2. Question paper will comprise of total six questions, each carrying 20 marks.
3. Question 1 will be compulsory and should cover maximum contents of the curriculum.
4. Remaining questions will be mixed in nature (for example if Q.2 has part (a) from module 3 then part (b) will be from any module other than module 3).
5. Only Four questions need to be solved.

Text Books/ Reference Books

1 Aarne Veslind and Alan E Rimer (1981), Unit operations in Resource Recovery Engineering , Prentice Hall Inc., London
2 Manser A G R, Keeling A A (1996). Practical handbook of processing and recycling on municipal waste. Pub CRC Lewis London, ISBN 1-56670-164
3 Chiumenti, Chiumenti, Diaz, Savage, Eggerth, and Goldstein, Modern Composting Technologies JG Press October 2005
4 Charles R Rhyner (1995),Waste Management and Resource Recovery, Lewis

Waste Technology: Semester VII		
Course Code	**Course Name**	**Credits**
HCWSBL701	**WASTE TECHNOLOGY SKILL BASED LAB**	**02**

Course Hours			Credits Assigned			
Theory	**Practical**	**Tutorial**	**Theory**	**Practical**	**Tutorial**	**Total**
-	**04**	**-**	**--**	**02**	**-**	**02**

Theory					Term Work / Practical/Oral		Total
Internal Assessment			End Sem Exam	Duration of End Sem Exam	TW	Oral	
Test-I	Test-II	Average					
-	-	-	-	----------	50	50	100

Course Objectives:-

Students will able to

1 Understand analyze properties of MSW
2 Understand vermicomposting on a lab scale.
3 Understand aerobic and anaerobic digesting of solid waste.
4 Will know of incineration process and handling of HSW.
5 Understand ecology baseline and impact of waste on environment.
6 Understand process of project report preparation based on case studies.

List of Experiments (minimum eight)

Waste Technology based experiments should be conducted.

1. Determination of pH of MSW
2. Determination of Total Solids, fixed solids and volatile solids
3. Determination of nutrient value (NPK)
4. Lab scale study on vermicomposting
5. Lab scale study of aerobic and anaerobic digesting of solid wastes (Both industrial & Municipal)
6. A Visit to the Hazardous waste Generation or disposal site.
7. Practical knowledge and working of incinerators
8. Visit to Industrial area, especially the handling of Hazardous materials
9. Ecology baseline and impact of waste – disposal on vegetation

10. Preparation of Project report based on a case study of one hospital Study of the source, generation rates and characteristics of hazardous wastes and their regulation, handling, treatment, and disposal. Special emphasis is placed on process design of waste handling, treatment and disposal systems.

Course Outcomes:

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

1 Learn to analyze properties of MSW.
2 To study vermicomposting on a lab scale.
3 To carry out aerobic and anaerobic digesting of solid waste.
4 To acquire knowledge of incineration process and handling of HSW.
5 Learn to analyze ecology baseline and impact of waste.
6 Learn about project report preparation based on case studies.

Term work (25 marks)

Term work should be evaluated based on performance in practical/Assignments.

Practical Journal/Assignments:	45 marks
Attendance:	05 marks
Total:	50 marks

End Semester Oral Examination (50 marks)

- A student will become eligible for Oral examination after completing 8 out of 10 experiments/Assignments