HAND BOOK
of
CURRICULUM STRUCTURE AND SYLLABUS

Master of Technology in Data Science (Programme Code: 3208)
Batch 2020-22

Institute of Engineering and Technology

Vision

To be one of India's most innovative higher education institutions.

Mission

To realise its vision, the University will:

Practice teaching that inculcates critical thinking and problem solving,

Pursue research that leads to innovation and enhancement of real-life applications,

Offer experience that leads to all round development, and

Develop a culture that is strongly rooted in interdisciplinarity and learning by building, not just doing.

Values

Caring for people.

Integrity including intellectual honesty, openness, fairness, and trust.

Commitment to excellence.

IQAC Documentation

Document Name: Handbook of Curriculum Structure and Syllabus, Master of Technology in Data Science (Programme Code: 3208) Batch 2020-2022

Document Compilation Date: Jan 24, 2022

Document Description: This document supplements the document titled Curriculum Structure: BTech, MTech and BCA Programs and is prepared by the Institute of Engineering and Technology (IET), JKLU to serve as an information baseline for further planning and delivery of courses w.r.t Master of Technology in Data Science (Programme Code: 3208) (M.Tech (DS)) , Batch 2020-2022.

It includes Program Education Objectives, Programme Outcomes, Programme Specific Outcomes, Desired minimum level of competence for POs and PSOs, Curriculum Structure, collation of Semester wise Course Description, and Course Articulation Matrix (CAM) of each course (including electives and additional courses, if any, opted by students) prepared by respective faculty members. The document also includes Programme Articulation Matrix (PAM).

This document is in compliance with BoS (upto 13th meeting) and approvals of the Academic Council (upto 20th meeting).

Document Creation Team:

Dr Sonal Jain

Dr Amit Sinhal

Santosh Verma

Umesh Tripathi

Quality Checked by:

Dr Devika Kataria

Dr Umesh Gupta

JK LAKSHMIPAT UNIVERSITY IQAC JAIPUR

Approved by:

DIRECTOR-IQAC
JK LAKSHMIPAT UNIVERSITY
JAIPUR

Vice Chancellor
JK Lakshmipat University
Jaipur-302026

CONTENTS

Program Education Objectives

The PG Programs at IET, JKLU are designed to prepare students for continued learning and successful careers. Our alumni are expected to:

PEO1: Apply their technical knowledge, complex problem solving and research skills in professional practice.

PEO2: Continue their intellectual development through critical thinking, self- study, apprenticeship, higher education, professional development courses, as well as participation in research groups and professional networks.

PEO3: Serve as ambassadors for engineering and sustainability by exhibiting high professional standards with a deep sense of civic responsibility.

PEO4: Effectively communicate about technical and related issues. PEO5:

Embrace roles of team members and leaders in their career.

Program Outcomes

The B.Tech and M.Tech. Programs at IET, JKLU are designed to prepare students for continued learning and successful careers. Our alumni are expected to:

PO 1: Life-long learning*:* Demonstrate inquisitiveness, open mindedness, and the ability to engage in independent and life-long learning in the broadest context of technological, organizational, economic, and societal changes.

PO 2: Citizenship, Sustainability, and Professional ethics

PO 2a: Demonstrate knowledge of constitutional values of liberty, equity, justice, and fraternity with understanding of the impact of the engineering solutions in societal and environmental contexts as well as a sense of responsibility for sustainable development.

PO 2b: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, cultural, and environmental issues and the consequent responsibilities relevant to the professional engineering practice.

PO 2c: Demonstrate commitment for professional integrity and excellence and respect for ethics, responsibilities and norms as prescribed for the engineering practice.

PO 3: Engineering knowledge and Modern tool usage

PO 3a: Demonstrate clear conceptual understanding of fundamentals of engineering specialization and cognitive flexibility to appropriately ‘transfer’ what has been learned in a context, to different situations.

PO 3b: Apply engineering thinking, computational thinking, and the knowledge of mathematics, natural and social sciences, engineering fundamentals, information technology, engineering specialization, and engineering management to the solution of complex engineering problems.

PO 3c: Create, select, modify, and apply appropriate techniques, best practices, standards, resources, and modern engineering and IT tools including prediction and modelling to engineering and social activities with an understanding of the limitations.

PO 4: Complex problem solving, Design and Research

PO 4a: Identify, formulate, review research literature, and analyze complex engineering problems to arrive at substantiated conclusions using critical thinking along with principles of mathematics, computing, engineering as well as natural and social sciences.

PO 4b: Use systems thinking and reflection to identify and consider underlying structures, patterns, volatility, uncertainties, complexities, ambiguities, complications, and risks to design and develop engineering solutions for complex problems to meet the specified and anticipated needs with appropriate concern for constraints, performance, sustainability, and professional ethics.

PO 4c: Use research-based knowledge and research methods including design of experiments, simulation, analysis and interpretation of data, and synthesis of the information to evaluate and improve the engineering solutions and practice.

PO 5: Individual & team work and Engineering management

PO 5a: Ability to work effectively as an individual and as a team member or leader in diverse and distributed teams, and in multidisciplinary settings.

PO 5b: Ability to apply engineering management principles to one's own and team's work to manage engineering projects and operations and in multidisciplinary environment.

PO 6: Communication: Ability to communicate effectively on complex engineering and technology activities, situations, problems, and solutions using verbal, textual, and pictorial elements with the colleagues, engineering community, users, clients, policy makers, and society at large with intellectual honesty, clarity, empathy, and compassion.

PO 7: Innovation and entrepreneurship:

PO 7a: Demonstrate enthusiasm and understanding to identify opportunities and translate research in engineering and other disciplines to conceive and design innovative engineering solutions for business, industry, and societal problems.

PO 7b: Demonstrate enthusiasm and understanding to conceive and plan technology based new ventures either as independent start-up businesses or within existing corporate structures.

Program Specific Outcomes

The Mtech Data Science graduates of JKLU will be able to:

DSPSO1: Identify, extract, and pull together available and pertinent heterogeneous data and use appropriate computational principles, platforms and techniques to discover new relations and deliver insights into research problem or organizational processes and support decision-making.

DSPSO2: Conceive, design, implement, and manage data analytics, data management and information systems, services, and processes by using principles of computer science, data management, machine learning, computational statistics, software engineering, and state of the art platforms, components and tools.

DSPSO3: Serve in the areas of data analytics, data science, or business analytics in business, consultancy, industry, government, healthcare, education, research, etc.

Program specific desired minimum level of competence for POs and PSOs

PO/PSO	Competence Level
PO 1	Competent
PO 2a	Novice
PO 2b	Novice/ Advanced Beginner
PO 2c	Novice
PO 3a	Competent
PO 3b	Advanced Beginner
PO 3c	Advanced Beginner
PO 4a	Advanced Beginner
PO 4b	Advanced Beginner
PO 4c	Advanced Beginner
PO 5a	Advanced Beginner
PO 5b	Advanced Beginner
PO 6	Advanced Beginner
PO 7a	Advanced Beginner
PO 7b	Novice
DSPSO 1	Competent (DSPSO1)
DSPSO 2	Competent (DSPSO2)
DSPSO 3	Competent (DSPSO3)
PSO4	NA

Following process has been adopted to create Course Articulation Matrix (CAM) and Program Articulation Matrix (PAM).

- Course Outcome of each Course is mapped to Program Outcome (PO) / Program Specific Outcome (PSO) using three Levels viz., Low Correlation (1), Moderate Correlation (2) and Substantial Correlation (3).

- Average of these Levels of each Course Outcome w.r.t each specific PO/PSO is calculated and it indicates expectations laid in a course to attain different PO/PSO. In order to avoid over-commitment of a course w.r.t its contribution to POs/PSOs, the following validation check is applied on the sum of PO/PSO wise averages in each course.

  $$\sum (\text{Average}) <= \text{Min}(\text{Credits} * \text{Year}, 20)$$

  In the above equation, Credits are the credits assigned to the course, Year (5 for 1st Year and 6 for 2nd Year) indicates the level of the students from 1st and 2nd year. In case this sum exceeds the upper limit, CO-PO mappings are revised. This check ensures that early or low credit courses are not overburdened with very high expectations.

- For the creation of the Program Articulation Matrix, the sum of these averages of different courses w.r.t each PO/PSO is calculated and interpreted as per the following Table.

Competence Level *	**M.Tech**
Novice	<5
Advanced Beginner	5 - 10
Competent	>=10

Novice* (N): Knows objective facts, features, and rules for determining actions wrt this PO/PSO without being context-sensitive. The student has studied the basic concepts.

Advanced beginner* (AB): Recognizes common situations w.r.t this PO/PSO that help in recalling which rules should be exercised, starts to recognize and handle situations not covered by given facts, features and rules. The student has problem-solving and repeated practice experience for common situations wrt this PO/PSO.

Competent* (C): Performs most standard actions w.r.t PO/PSO without conscious application of rules after considering the whole situation. Handles new situations through the appropriate application of rules, can design systems, and may lead. Has demonstrated this PO/PSO through repeated engagements in advanced problem-solving, projects, extensive practice in common and exception situations, and participated in professional networks.

JK Lakshmipat University, Jaipur
Institute of Engineering and Technology
Curriculum Structure
Master of Technology in Data Science (Batch 2020-2022)

Sem	Courses						Credits
I	Statistical Data Analysis AS2101 (3 0 4) 5	Cloud based Big Data System-I CS2101 (3 0 2) 4	Machine Learning and Data Mining CS2102 (3 0 4) 5	Project-I PR2101/ Research Methodology -I IL2107 (2 0 0) 2	Critical Thinking for Developing Perspectives CC2171 (2 0 0) 2	Elective-I (3 0 0) 3	**21**
II	Statistical Data Analysis-II AS2104 (3 0 4) 5	Cloud based Big Data System-II CS2114 (3 0 2) 4	Applied Advanced Machine Learning CS2115 (3 0 4) 5	Project-II PR2102/ Research Methodology-II IL2108 (2 0 0) 2	Critical Thinking for Decisions at Workplace CC2114 (2 0 0) 2	Elective-II (3 0 0) 3	**21**
PS2101-Internship (6- 8 weeks)							**4**
Exit Option with PG Diploma							
III	Dissertation-I/ Industrial Project-I/ Entrepreneurial Project-I PR2103/ PR2104/ PR2105 10		Elective-III (3 0 0) 4			Elective -IV (3 0 0) 4	**18**
IV	Dissertation-II/ Industrial Project-II/ Entrepreneurial Project-II PR2106/ PR2107/ PR2108 16						**16**
							80

Elective-I
Robotic Process Automation and Applications- CS2103
Industrial Automation and IoT-I- EE2101
Elective-II
Web Algorithms and Analytics
Computer Vision-EE2201
Elective-III/IV
Natural Language Processing- CS2203
Large Scale Graph Analytics- CS2201
Special Topics in Data Science

NOTE:

1. Students have the option to exit the program with a PG Diploma after completing one year and internship.
2. For every credit, in each course, every student is expected to put in a total work of 35-36 hours including the class time. The specified teaching scheme is applicable if the course is taught as full semester course. However, sometimes, a few courses may actually be completed in a shorter duration by increasing the weekly contact hours.
3. Learning outcomes focus on higher order thinking and practical skills. Rote learning is completely de-emphasized and assessment scheme in several components like assignments, labs, projects, reports etc. The exams are designed to assess problem solving ability through questions focusing on analysis, synthesis, and evaluation.
4. Relevant engineering standards and sustainability issues are incorporated in all engineering courses.
5. A student may sometimes be allowed to take a few additional courses for earning extra credits, fulfilling credit deficiency or completion of academically equivalent core course requirements in special cases.

Course Title and Code: Statistical Data Analysis (AS2101)		
Hours per Week	**L-T-P: 3-0-4**	
Credits	**5**	
Students who can take	M.Tech. Semester-I	

Course Objective:

This course aims to introduce basic concepts in descriptive and inferential statistics, as well as data exploration methods. Topics covered include probability distributions, hypothesis testing, frequency analysis, correlation, regression and design of experiments.

After course completion, the student will be able to:

AS2101.1. Frame real world analysis problems using statistical concepts and solve them using standard techniques.

AS2101.2. Use professional level tools to support the study of statistics.

AS2101.3. Communicate quantitative ideas to a range of audiences.

AS2101.4. Apply recommended practices for data analysis.

Prerequisites		
Sr. No	**Specifications**	**Marks**
1	Attendance	Nil
2	Assignment	Nil
3	Class Participation	10
4	Quiz	15
5	Theory Exam-I	Nil
6	Theory Exam-II	Nil
7	Theory Exam-III	30
8	Report-I	Nil
9	Report-II	Nil
10	Report-III	Nil
11	Project-I	25
12	Project-II	Nil
13	Project-III	Nil
14	Lab Evaluation-I	20
15	Lab Evaluation-II	Nil
16	Course Portfolio	Nil
	Total (100)	Nil

SYLLABUS

Theory:

Principles of Statistical Data Analysis: Data Elements, Variables, and Data categorization, Levels of Measurement: Nominal, Ordinal, Interval, or Ratio, Data management and indexing, Tabular data, Measures of dispersions, Skewness – Karl Pearson and Bowley, Skewness – Kelly coefficient of Skewness and Kurtosis

Probability Theory, Mathematical expectation, moments, probability and moment generating function, Chebyshev's inequality, Mean and Variance of a Random Variable, product moments, independence of random variables, Joint, marginal and conditional distributions, Discrete and continuous distribution function, Introduction to statistical learning using R-Programming/Python

Basic Statistical Techniques: Sampling Theory and Distributions for Normal and Non-normal Populations, Central Limit Theorem, Point and Interval Estimates, Estimator and Estimates, Sample size calculations Sample Size for Estimating Means and Proportions, Maximum likelihood test, The Central Limit Theorem, p-values and power, Parametric and Non-Parametric test of Hypothesis, Goodness of fit, Analysis of contingency tables, Non-parametric tests of location and dispersion,

Statistical inference using R/Python

Analysis of Continuous and Categorical Data: Estimation Using the Regression Line, Method of Least Squares, Standard Error of Estimate, Prediction Intervals, Multi Variate regression, generalized linear models, Logistic regression, Ordinal logistic regression, Proportional odds models, Multinomial logistic regression, Poisson regression, negative binomial regression, zero-inflated models, Log linear models for (paired) tables. Procedures for stepwise building of a regression model, Introduction to random intercept models, penalized linear regression methods, Graphical and formal diagnostic methods for the inspection of residuals, Correlation Analysis, autocorrelation and cross correlation, Regression and Correlation analysis using R/Python

Design of experiments: Basic principles of experimental designs, Analysis of variance: one-way, Two-way classifications, Latin square design, Two Factorial Design.

Practical: Solve the problems mentioned in theory classes using packages like Python, NumPy, Pandas, statistical package SciPy, Stats, scikit-learn, plotting packages Matplotlib and Seaborn.

Text Book(s)

1. Prem S Mann. Introductory statistics. Wiley. Edition: 7th ed. 2010.
2. Ronald E Walpole, Raymond H Myers, Sharon L Myers and Keying Ye. Probability and statistics for engineers and scientists. 8th ed - New Delhi. Pearson. 2007.

Web Resources

1. Statistics full Course for Beginners. https://www.youtube.com/watch?v=74oUwKezFho
2. Introduction to R and R Studio. https://www.youtube.com/watch?v=lL0s1coNtRk

Course Articulation Matrix: (Mapping of COs with POs)

CO		CORRELATION WITH PROGRAM OUTCOMES														CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
	PO 1	PO 2a	PO 2b	PO 2c	PO 3a	PO 3b	PO 3c	PO 4a	PO 4b	PO 4c	PO 5a	PO 5b	PO 6	PO 7a	PO 7b	PSO 1	PSO 2	PSO 3
AS2101.1	2				2													
AS2101.2							2											
AS2101.3													2					
AS2101.4														2				

Course Title and Code:	Cloud based Big Data System-I: CS2101
Hours per Week	**L-T-P: 3-0-2**
Credits	**4**
Students who can take	M.Tech. Sem I

Course Objective- This course prepares students to use the Big Data platform and methodologies in order to collect and analyze large amounts of data from different sources. The students will acquire skills in Big Data architecture, such as Apache Hadoop, Ambari, Spark, Big SQL, HDFS, YARN, MapReduce, ZooKeeper, Knox, Sqoop, and HBase.

Learning Outcomes:

After completing this course, the students should be able to understand the following topics:

CS2101.1. Explain Big Data technologies challenges and solutions for businesses.

CS2101.2. Illustrate Apache Hadoop, Ambari, Spark, HDFS, YARN, MapReduce, Pig, ZooKeeper, Knox, Sqoop, and HBase.

CS2101.3. Execute job on MapReduce framework.

CS2101.4. Demonstrate the process of add and removal nodes from Hadoop clusters, check available disk space on each node, modify configuration parameters.

CS2101.5. Use Hive to Access Hadoop Data.

CS2101.6. Organize Apache Sqoop and Flume to Move Data into Hadoop.

CS2101.7. Apply Pig's relational operators, evaluation functions, and math and string functions.

CS2101.8. Develop Data Pipelines with Apache Kafka.

CS2101.9. Design Hadoop ecosystem for a Big Data application.

Prerequisites		Linux, Programming, SQL
Sr. No	**Specifications**	**Marks**
01	Attendance	Nil
02	Assignment	Nil
03	Class Participation	Nil
04	Quiz	15
05	Theory Exam-I	Nil
06	Theory Exam-II	Nil
07	Theory Exam-III	25
08	Report-I	20
09	Report-II	Nil
10	Report-III	Nil
11	Project-I	Nil
12	Project-II	Nil
13	Project-III	Nil
14	Lab Evaluation-I	20
15	Lab Evaluation-II	20
16	Course Portfolio	Nil
	Total (100)	**100**

Syllabus (Theory)

Big Data Overview: Data Overview, Industry Applications, Case Studies, Understanding Big Data
Big Data and Analytics: Hortonworks Data Platform (HDP), Apache Ambari, Hadoop and the Hadoop Distributed File System, MapReduce and YARN, Apache Spark, Storing and Querying data, ZooKeeper, Slider, and Knox. Loading data with Sqoop, DataPlane Service, Stream Computing,
Data Science essentials, Drew Conway's Venn Diagram - and that of others, The Scientific Process applied to Data Science, The steps in running a Data Science project, Languages used for Data Science

(Python, R, Scala, Julia, ...), Markdown language with notebooks, Resources for Data Science, including GitHub, Jupyter Notebook, Essential packages: NumPy, SciPy, Pandas, Scikit-learn, NLTK, BeautifulSoup..., Data visualizations: matplotlib, ..., PixieDust, Using Jupyter "Magic" commands, Using Big SQL to access HDFS data, Creating Big SQL schemas and tables, Querying Big SQL tables, Configuring Big SQL security, Data federation with Big SQL

Reference Books:

1. Benjamin Bengfort and Jenny Kim. Data Analytics with Hadoop: An Introduction for Data Scientists. O'Reilly Media, 2016.
2. Jake VanderPlas. Python Data Science Handbook: Essential Tools for Working with Data. O'Reilly Media, 2016.

Course Articulation Matrix: (Mapping of COs with POs)

CO		CORRELATION WITH PROGRAM OUTCOMES														CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
	PO 1	PO 2a	PO 2b	PO 2c	PO 3a	PO 3b	PO 3c	PO 4a	PO 4b	PO 4c	PO 5a	PO 5b	PO 6	PO 7a	PO 7b	PSO 1	PSO 2	PSO 3
CS2101.1	2		1	2	2		1	2		1		2				1		2
CS2101.2	2			1		2		2		2				2		1		2
CS2101.3	2	1	1	2						2	1	2	2		1	1		1
CS2101.4	1			2	1	2	2	2			2		2	1	2		3	3
CS2101.5	3	1				1		1		2	2				1	2	2	3
CS2101.6	2		1		1	2	1			1				3	2	2	3	3
CS2101.7	1	1				3	2	2	3		2	3			3	3	2	2
CS2101.8					2	1		3	2	2	2	2		2	1	2	2	3
CS2101.9	2		1	2	2		1	2		1		2				1		2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Course Title and Code: Machine Learning and Data Mining CS2102	
Hours per Week	**L-T-P: 3-0-4**
Credits	**5**
Students who can take	M. Tech Sem I

Course Objective: This course introduces the fundamental concepts of machine learning and data mining techniques. The course will cover the state-of-the art data mining techniques along with its usage with machine learning algorithms on real-world data (or big data). This course helps the students to pursue project related ML and data mining with real-world research problems.

Course Outcome:

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

1. Utilize advanced knowledge of data mining, data warehousing and KDD concepts and techniques.
2. Organize and prepare the data needed for data mining using pre-preprocessing techniques.
3. Generate and apply different mining techniques such as rule generation, association mining, Bayesian techniques and Frequent Itemset generation.
4. Apply the techniques of clustering, classification, association finding, feature selection and visualization for large datasets.
5. Explain the underlying mathematical relationships within and across Machine Learning algorithms and the paradigms of supervised and un-supervised learning.
6. Select and apply suitable machine learning techniques for a given problem.

Prerequisites		Nil
Sr. No	**Specifications**	**Marks**
1	Attendance	Nil
2	Assignment	10
3	Class Participation	10
4	Quiz	10
5	Theory Exam	20
6	Theory Exam	Nil
7	Theory Exam	Nil
8	Report-1	10
9	Report-2	Nil
10	Report-3	Nil
11	Project -1	20
12	Project -2	Nil
13	Project -3	Nil
14	Lab Evaluation1	Nil
15	Lab Evaluation2	20
16	Course portfolio	Nil
	Total (100)	100

Syllabus (Theory)

UNIT – I: Introduction: Data warehouse – Difference between Operational DBs and Data warehouses – Multidimensional Data Model, The process of knowledge discovery in databases, predictive and descriptive data mining techniques, supervised and unsupervised learning techniques.

UNIT – II: Techniques of Data Mining: Link analysis, predictive modeling, database segmentation, score functions for data mining algorithms, Bayesian techniques in data mining, Association Analysis: Problem Definition; Frequent Itemset generation; Rule Generation; Compact representation of frequent itemsets; Alternative methods for generating frequent item-sets

UNIT – III: Issues in Data Mining: Scalability and data management issues in data mining algorithms, parallel and distributed data mining, privacy, social, ethical issues in Knowledge Discovery in Databases (KDD) and data mining, pitfalls of KDD and data mining.

UNIT – IV: Introduction to Machine Learning, Supervised Learning: Classification: Preliminaries; General approach to solving a classification problem; Decision tree induction; Rule-based classifier; Simple and Multiple Linear Regression; Nearest-neighbor classifier, SVM, Unsupervised Learning: Clustering; K-Means, Hierarchical Clustering

UNIT – V: Model Evaluation Measures: Cross-Validation Technique, Confusion matrix for evaluation, Class probabilities and class predictions, ROC Curve, Model evaluation metrics, Fitting dataset and evaluating their performance set, Evaluation of selected features, Model evaluation metrics, making predictions on new data

Usage of AI and ML Techniques for achieving sustainable practices, NIST and IEEE standards for AI and ML libraries, tools and techniques

Reference Books:

1. Mitchell, Tom. Machine Learning, McGraw Hill 1997.
2. Murphy, Kevin P. Machine learning: a probabilistic perspective. MIT press, 2012. (Electronic copy available through the Bodleian library.)
3. Bishop, Christopher M. Pattern recognition and machine learning. Springer, 2006.
4. Han, Jiawei, Jian Pei, and Micheline Kamber. Data mining: concepts and techniques. Elsevier, 2011.
5. Tan, Pang-Ning, Michael Steinbach, Vipin Kumar, and Anuj Karpatne. Introduction to Data Mining, Global Edition. Pearson Education Limited, 2019.
6. Witten, Ian H., Eibe Frank, Mark A. Hall, and Christopher J. Pal. Data Mining: Practical machine learning tools and techniques. Morgan Kaufmann, 2016.

Course Articulation Matrix: (Mapping of COs with POs)

	PO1	PO 2a	PO 2b	PO 2c	PO 3a	PO 3b	PO 3c	PO 4a	PO 4b	PO 4c	PO 5a	PO 5b	PO6	PO 7a	PO 7b	PS O1	PS O2	PS O3
CS2102.1	1				2		2	2	1	2				1	1	2		1
CS2102.2					2	1	1	1	1	1	2						1	1
CS2102.3	1			1		2	1	1	1	1	1	1		1		1	2	2
CS2102.4	1			1		1	1	1	2	2	1	1				2	2	
CS2102.5	1			1		2	2	2	1	2	2	2		2	2	1		2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Course Title and Code: Project-I: PR2101	
Prerequisites	**Nil**
Hours per Week	**L-T-P: 2-0-0**
Credits	**02**
Students who can take	**M.Tech. Semester I**

Course Objective: The course aims to equip the students with knowledge of the nuances of building a project utilizing the concepts either attained in undergraduate or in parallel being attained in semester I. The course includes basics of preparation of project proposal, project creation and management cycle, team work, converting into a usable application and test cases to evaluate the project and preparation of report of project.

Learning Outcome

PR2101.1. Identify project goals, constraints, deliverables, performance criteria, control needs, and resource requirements to serve requirement

PR2101.2. Implement project management knowledge, processes, lifecycle and the embodied concepts, tools and techniques in order to achieve project success

PR2101.3. Utilize technology tools for communication, collaboration, information management, and decision support

PR2101.4. Apply appropriate legal and ethical standards.

PR2101.5. Test the Project with varied test cases.

Sr. No	**Specifications**	**Marks**
01	Attendance	NIL
02	Assignment	NIL
03	Class Participation (Day to Day work)	30
04	Quiz	NIL
05	Theory Exam	NIL
06	Theory Exam	NIL
07	Theory Exam (Final)	NIL
08	Report-1 (Synopsis)	10
09	Report-2 (Final report)	20
10	Report-3	NIL
11	Project -1	40
12	Project -2	NIL
13	Project -3	NIL
14	Lab Evaluation – I	NIL
15	Lab Evaluation – II	NIL
16	Course portfolio	NIL
	Total (100)	**100**

Course Articulation Matrix: (Mapping of COs with POs)

CO	CORRELATION WITH PROGRAM OUTCOMES															CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
	PO 1	PO 2a	PO 2b	PO 2c	PO 3a	PO 3b	PO 3c	PO 4a	PO 4b	PO 4c	PO 5a	PO 5b	PO 6	PO 7a	PO 7b	PSO 1	PSO 2	PSO 3
PR2101.1	1				1			1			1					1	1	1
PR2101.2					1			1		1		1				1	1	1
PR2101.3						1		1	1	1		1				1	1	1
PR2101.4			1			1	1		1	1	1			1				
PR2101.5	1					1	1		1	1	1	1			1	1	1	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Course Name: Critical Thinking for Developing Perspectives – CC2171
Prog. & Semester: Mtech Sem I
Credit: 2

Course Description

The ability to clearly reason through problems and to present arguments in a logical, and compelling way, have become a key skill for survival in today's world. In this course, students will learn to dissect and evaluate the components of argument. Students will learn to raise vital questions, think from multiple perspectives, become aware of their biases, gather and assess information and come to a well-reasoned position.

Course Outcomes:

The students will be able to:
CC2171.1. Explain the relevance of critical thinking
CC2171.2. Formulate significant questions for inquiry.
CC2171.3. Evaluate information and evidence for correctness, consistency, and relevance.
CC2171.4. Compose well-structured and well-reasoned arguments.
CC2171.5. Recognize their own beliefs, biases, claims and assumptions by viewing the issues from multiple perspectives

Evaluation Scheme

Prerequisites		**N/A**
Hours per Week		**L-T-P: 2-0-1**
Credits		**2**
Sr. No	**Specifications**	**Weightage**
01	Attendance	Nil
02	**Assignment**	**40**
03	**Class Participation**	**20**
04	**Quiz**	**20**
05	Theory Exam	Nil
06	Theory Exam	Nil
07	**Theory Exam**	**20**
08	Report-1	Nil
09	Report-2	Nil
10	Report-3	Nil
11	Project -1	nil
12	Project -2	Nil
13	Project -3	Nil
14	Lab Evaluation	Nil
15	Lab Evaluation	Nil
16	Course portfolio	Nil
	Total (100)	**100**

Pedagogy

This course will be an amalgamation of lectures and activity-based learning i.e., films, group discussions, debates, and case studies. The objective behind utilizing activity-based learning is for the learners to have a more hands on experience.

❖ **Topics to be Covered**

I. Introduction to the concept of critical thinking:

· Evolution of the concept: Philosophy and Cognitive psychology as origins of critical thinking

· Revisit Paul-Elder Critical Thinking Framework

II. Questioning for Critical Thinking

· Importance of questioning

· Models of Questioning: Questioning Circles Model, Christenbury and Kelly (1983), Webb's Depth of Knowledge (1997). Elder & Paul (2007). Socratic Questioning Taxonomy.

III. Understanding Arguments

The sessions under this topic will make use of the context of current media, social and political debates to comprehend the topics.

· Meaning and Elements of Reasoning

· Formation of Arguments: Premise and Conclusion

· Inductive –Deductive reasoning: Difference between valid and invalid arguments/ between sound and unsound arguments.

· Evaluating Arguments: Examining data and information critically

· Cognitive Biases and Fallacies: Distinguishing between fact and opinion

Readings/Video(s)

1. The Evolution of Critical Thinking (Research project by Barba Albers, Washington, State University ,2004

2. Bowker, M. H., & Fazioli, K. P. (2016). Rethinking Critical Thinking: A Relational and Contextual Approach. Pedagogy and the Human Sciences, 6(1), 1-26.

3. Bauer, N. J. (1991). Dewey and Schon: An Analysis of Reflective Thinking.

4. Nappi, J. S. (2017). The importance of questioning in developing critical thinking skills. Delta Kappa Gamma Bulletin, 84(1), 30.

5. https://cpb-us e1.wpmucdn.com/cobblearning.net/dist/6/3101/files/2018/05/The-Importance-of-Questioning-2aqkc5j.pdfBloom, B. S. (1956). Taxonomy of educational objectives. Vol. 1: Cognitive domain. New York: McKay, 20-24.

6. Paul, R., & Binker, A. J. A. (1990). Socratic questioning. Critical thinking. Center for Critical Thinking and Moral Critique.
http://www.criticalthinking.org/files/SocraticQuestioning2006.pdf

7. The Art of Asking Questions | Dan Moulthrop | TEDxSHHS
https://www.youtube.com/watch?v=hZSY0PssqH0

8. Analysing the argument - Part 1 of 2 (Video)

Reference Books:

1. Moore, B. N., & Parker, R. (2009). Critical thinking. Boston, MA: McGraw-Hill. eBook
2. Sinnott-Armstrong, W., & Fogelin, R. J. (2014). Cengage Advantage Books: Understanding Arguments: An Introduction to Informal Logic. Cengage Learning eBook

CO		CORRELATION WITH PROGRAM OUTCOMES														CORRELATIO N WITH PROGRAM SPECIFIC OUTCOMES		
	PO 1	PO 2a	PO 2b	PO 2c	PO 3a	PO 3b	PO 3c	PO 4a	PO 4b	PO 4c	PO 5a	PO 5b	PO 6	PO 7a	PO 7b	PSO 1	PSO 2	PSO 3
C2171.1	2						1	2										
C2171.2	2		1					2							1			
C2171.3	2		2	1			1	1		1								
C2171.4	2								1				1					
C2171.5	2										2							

Course Title and Code: Robotic Process Automation and Applications CS2103	
Hours per Week	**L-T-P: 3-0-4**
Credits	**5**
Students who can take	Mtech DS, Mtech A & R

Course Objective:
The course aim is to develop understanding about Robotic Process Automation for automating business processes using software robots with cost efficient digital delivery.

Learning Outcome:
On successful completion of this course, the students should be able to:

CS2103.1. Use and understand the various functionalities and features of UiPath Studio and Orchestrator.
CS2103.2. Design, implement, and use RPA activities.
CS2103.3. Develop basic robots using UiPath Community Edition.
CS2103.4. Explore various data extraction techniques.
CS2103.5. Deploy, monitor and control robots with UiPath Orchestrator.
CS2103.6. Identify processes which can be automated.
CS2103.7. Apply best practices in RPA projects.

Prerequisites: To understand and complete the course successfully the student must have basic programming skills.

Sr. No	**Specifications**	**Marks**
01	Attendance	Nil
02	Assignments	10
03	Class Participation	10
04	Quiz	20
05	Theory Exam	Nil
06	Theory Exam	Nil
07	Theory Exam (Final)	Nil
08	Report-1	Nil
09	Report-2	Nil
10	Report-3	Nil
11	Project-1	20
12	Project-2	20
13	Project-3	Nil
14	Lab Evaluation-1	10
15	Lab Evaluation-2	Nil
16	Course portfolio	10
	Total (100)	**100**

Retest

1	Quiz	20
2	Lab Evaluation-1	10

Syllabus (Theory):

Unit I: Programming Basic & Recap: Programming concept basic; **Introduction to RPA:** scopes and techniques of automation, RPA components and various RPA platforms, Introduction to UiPath as RPA platform, Applications and Benefits of RPA, Introduction to UiPath Studio, UiPath robot, types of robots, and UiPath Orchestrator. Brief on Studio interface and components.

Unit II: **RPA Projects:** Types of Projects in RPA: Sequence, Flowcharts, and State machines; Variables, Arguments, Data Types and Control flow: flow chart activities and sequences activities. **Data Manipulation:** Text and Data Manipulation**,** Data tables, clipboard management, file operation, importing from and exporting to CSV/Excel file and data table.
Unit III: **Control of Controls:** Attach window activity, Finding the control, Waiting for a control, Act on Control- mouse and keyboard activity. Handling event driven controls as working with UiExplorer handling events. Introduction to Recorder, OCR, types of OCR and Screen Scrapping Using OCR. **Selectors:** Selectors, Defining and Assessing Selectors, Customization, Debugging, Dynamic Selectors, Partial Selectors, RPA Challenge.
Unit IV: **Application with Plugins and Extensions:** Java plugins, Citrix automation, Mail plugins, PDF plugins, Web integration, excel and word plugins. Extensions- Java, chrome, firefox, and Silverlight. **UiPath Advanced Automation concepts and techniques:** Image, Text and introduction of Citrix Automation; **Excel Data Tables & PDF:** Data Tables in RPA, Excel and Data Table basics, Data Manipulation in excel, Extracting Data from PDF, Extracting a single piece of data, Anchors. **Email Automation:** Incoming Email automation, Sending Email automation.
Unit V: **Debugging and Exception Handling:** Common exceptions and ways to tackle them, Strategies for solving issues, Catching errors. **Introduction to Orchestrator:** Tenants, Authentication, Robots, Environments, Asset. **Capstone Project.**

Syllabus (Practical):

1. Setup, configuration, and introduction of components of UiPath Studio.
2. Execution of prebuilt examples of sequence, flow chart and state machines projects.

Create a sequence/Flow chart activity defining various types of variables as:

3. Generic Value Variables, Text Variables, Boolean Variables, Number Variables,
4. Array Variables, Date and Time Variables, Data Table Variables

Managing Arguments:

5. Create two activities, one activity defined with arguments and second activity which manages the argument to receive value from first activity.
6. Create an activity to manage importing active namespaces.

Create a project to Manage the control Flow:

7. The Assign Activity, The Delay Activity, The Do While Activity, The If Activity
8. The Switch Activity, The While Activity, The For-Each Activity, The Break Activity.

The Recording toolbar Activity:

9. Exercises using basic, web, and Desktop recoding.
10. Automate manual recording projects on Left-click on buttons, check boxes, drop-down lists, GUI elements, and Text typing

Data Scrapping:

11. Bot to extract structured data from your browser, application or document to a database, .csv file or even Excel spreadsheet.
12. Image and Text Automation
13. Excel Data Tables & PDF
14. Email Automation
15. Deployment of plugins and extensions.
16. Deploying and maintaining the BOT.

Text Books:

T1 Tripathi, Alok Mani. Learning Robotic Process Automation: Create Software robots and automate business processes with the leading RPA tool–UiPath. Packt Publishing Ltd, 2018.
T2. Murdoch, Richard. "Robotic Process Automation: Guide to Building Software Robots, Automate Repetitive Tasks & Become An RPA Consultant." Middletown, DE. Omakustanne (2018).

Reference Books:

R1. Abhinav Sabharwal, “Introduction To RPA”, Independently Published Kindle Edition on Amazon Asia-Pacific Holdings Private Limited, 201 8
R2. Gerardus Blokdyk, “Rpa Robotic Process Automation”, 5Starcook, Second Edition, 2018
R3. Kelly Wibbenmeyer, “The Simple Implementation Guide to Robotic Process Automation (Rpa): How to Best Implement Rpa in an Organization” Paperback, iUniverse, 2018
R4. Willcocks, Leslie P., Mary Lacity, and Andrew Craig. "The IT function and robotic process automation." (2015).

Course Articulation Matrix: (Mapping of COs with POs)

CO		CORRELATION WITH PROGRAM OUTCOMES														CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
	PO 1	PO 2a	PO 2b	PO 2c	PO 3a	PO 3b	PO 3c	PO 4a	PO 4b	PO 4c	PO 5a	PO 5b	PO 6	PO 7a	PO 7b	PSO 1	PSO 2	PSO 3
CS2103.1	1				1												2	
CS2103.2		1				1		2			1		1	1		2	3	
CS2103.3	1				1					1	1			2		3	3	
CS2103.4					1					1			1			3		
CS2103.5							1			1				1			3	
CS2103.6	1		1		1								1	1		3	3	
CS2103.7		1	1				1									3	3	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Course Title and Code: Statistical Data Analysis-II: AS2104	
Hours per Week	**L-T-P: 3-0-4**
Credits	**5**
Students who can take	M. Tech. Sem II (2020-2022)

Course Objective: This course introduces the various advanced statistical methods and models related to data analysis. The course objective is to make the students capable with statistical modeling and problem-solving skills using concepts such as Bayesian statistics, experimental design, time series analysis and forecasting, reliability, etc.

Learning Outcomes:

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

AS2104.1. Apply statistical tools in design, research and development.

AS2104.2. Apply the concept of Bayesian statistics, design of experiments, time series analysis, etc. in data-based problems.

AS2104.3. Formulate and solve problems which involve setting up stochastic models.

AS2104.4. Construct fractional factorial experiments and apply confounding in problem solving.

AS2104.5. Apply classification techniques to solve data related problems.

Prerequisites	**Basic Statistics**

Evaluation Scheme

Sr. No	**Specifications**	**Marks**
1	Attendance	Nil
2	Assignment	Nil
3	Class Participation	10
4	Quiz	20
5	Theory Exam I	Nil
6	Theory Exam II	20
7	Theory Exam III	20
8	Report-1	Nil
9	Report-2	Nil
10	Report-3	Nil
11	Project -1	Nil
12	Project -2	Nil
13	Project -3	Nil
14	Lab Evaluation1	Nil
15	Lab Evaluation2	30
16	Course portfolio	Nil
	Total (100)	**100**

Retest Evaluation Scheme		
1	Theory Exam - III	20
2	Lab Evaluation2	30
	Total (30)	**50**

Syllabus

Unit 1: Bayesian Statistics

Bayesian versus frequentist probability, prior distributions, the likelihood function, posterior distribution, Markov Chain Monte Carlo methods, logit, probit, longitudinal data analysis, Bayesian hypothesis testing, Bayesian variable selection, Bayesian decision theory

Unit 2: Experimental Design

General concepts, ANOVA, full and fractional factorial designs, multiple comparisons, designs with randomization restrictions, orthogonal designs

Unit 3: Data Estimation and Forecasting

Density estimation, Recursive partitioning, Survivals analysis, Principal component analysis, Multidimensional scaling, Cluster analysis, Time series analysis and forecasting, Reliability theory

Text Book:

1. Rishard A. Johnson, Miller and Freund's probability and Statistics for Engineers, PHI, 9th global edition (2018).

Reference Books:

1. Douglas C. Montgomery and George C. Runger, Applied Statistics and Probability for Engineers, John Wiley & Sons, Inc., 3rd Edition (2004).
2. Larsen, Richard J. and Marx, Morris L. An Introduction to Mathematical Statistics and its Applications, Prentice Hall, 5th edition (2012).
3. Milton, J. Susan and Arnold, Jesse C. Introduction to Probability and Statistics. McGraw Hill, 4th edition (2013).

CO		CORRELATION WITH PROGRAM OUTCOMES														CORRELATIO N WITH PROGRAM SPECIFIC OUTCOMES		
	P O 1	P O 2a	P O 2b	P O 2c	P O 3a	P O 3b	P O 3c	P O 4a	P O 4b	P O 4c	P O 5a	P O 5b	P O 6	P O 7a	P O 7b	PSO 1	PSO 2	PSO 3
AS2104.1	2				1	2			1					1				1
AS2104.2			1					1		2								
AS2104.3			1					1		1							1	
AS2104.4			1					1		1								
AS2104.5								1										

Course Title and Code:	Cloud Based Big Data System-II: CS2114
Hours per Week	**L-T-P: 3-0-2**
Credits	**4**
Students who can take	M.Tech. in Data Science (2nd Semester)

Course Objective: The course presents a top-down view of cloud computing, from applications and administration to programming and infrastructure. The main focus is on deployment of solution elements, including infrastructure components such as networks, systems and applications services in the cloud infrastructure. This course also introduces the important concepts and terminology for working with Google Cloud Platform (GCP). The students will learn about the infrastructure, core services, scaling and automation, design and process, and Kubernetes engine of Google Cloud.

Learning Outcomes:

After completing this course, the students should be able to:

CS2114.1. Explain the core concepts of the cloud computing paradigm: how and why this paradigm shift came about, the characteristics, advantages and challenges brought about by the various models and services in cloud computing

CS2114.2. Apply fundamental concepts in cloud infrastructures to understand the tradeoffs in power, efficiency and cost

CS2114.3. Build and deploy cloud applications that are resilient, elastic and cost-efficient

CS2114.4. Analyze the trade-offs between deploying applications in the cloud and over the local infrastructure.

CS2114.5. Compare the advantages and disadvantages of various cloud computing platforms.

CS2114.6. Deploy applications over commercial cloud computing infrastructures, i.e., Google Cloud

CS2114.7. Analyze the performance, scalability, and availability of the underlying cloud technologies and software

CS2114.8. Identify security and privacy issues in cloud computing

Evaluation Scheme:

Sr. No	**Specifications**	**Marks**
01	Attendance	Nil
02	Assignment	15
03	Class Participation	Nil
04	Quiz	15
05	Theory Exam-I	Nil
06	Theory Exam-II	Nil
07	Theory Exam-III	25
08	Report-I	Nil
09	Report-II	Nil
10	Report-III	Nil
11	Project-I	25
12	Project-II	Nil
13	Project-III	Nil
14	Lab Evaluation-I	20
15	Lab Evaluation-II	Nil
16	Course Portfolio	Nil
	Total	**100**
Evaluation Scheme for Retest		
01	Theory Exam-III	25
02	Lab Evaluation-I	20
	Total	**45**

Syllabus:

Cloud Computing Overview: Definition and evolution of Cloud Computing, Enabling Technologies, Service and Deployment Models, Popular Cloud Stacks and Use Cases, Benefits, Risks, and Challenges of Cloud Computing, Economic Models and SLAs, Topics in Cloud Security Cloud Infrastructure: Historical Perspective of Data Centres, Datacentre Components: IT Equipment and Facilities, Design Considerations: Requirements, Power, Efficiency, & Redundancy, Power Calculations, PUE and Challenges in Cloud Data Centres, Cloud Management and Cloud Software Deployment Considerations

Google Cloud Platform Fundamentals: Google App Engine, Google Compute Engine, Google Kubernetes Engine, Google Cloud Storage, Google Cloud SQL, and BigQuery, Google Cloud Resource Manager hierarchy and Google Cloud Identity and Access Management, infrastructure design, and virtual networking configuration with Virtual Private Cloud (VPC), Projects, Networks, Subnetworks, IP addresses, Routes, and Firewall rules

Google Cloud Infrastructure: Compute Engine, Core Services, customer-supplied encryption keys, security and access management, quotas and billing, and resource monitoring, Scaling and Automation, securely interconnecting networks, load balancing, auto-scaling, infrastructure automation and managed services, Design and Process, define and balance business and technical requirements to design Google Cloud deployments, Kubernetes Engine, Creating and managing software containers and an introduction to the architecture of Kubernetes.

Cloud Computing Standards- Introduction- Objectives, Best Practices and Standards, Practical Issues- Interoperability- Portability- Integration- Security

Reference Books:

1. Thomas Erl, Ricardo Puttini, Zaigham Mahmood. *Cloud Computing: Concepts, Technology & Architecture*. Pearson, 2013.
2. Dan Sullivan. *Official Google Cloud Certified Associate Cloud Engineer Study Guide*. Sybex, 2019.
3. Michael J. Kavis. *Architecting the Cloud: Design Decisions for Cloud Computing Service Models*. Wiley, 2014.

Suggested MOOCs:

- Cloud Architecture with Google Cloud Professional Certificate

www.coursera.org/professional-certificates/gcp-cloud-architect

- Cloud Computing

https://www.coursera.org/specializations/cloud-computing

Course Articulation Matrix: (Mapping of COs with POs)

CO		CORRELATION WITH PROGRAM OUTCOMES														CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
	PO 1	PO 2a	PO 2b	PO 2c	PO 3a	PO 3b	PO 3c	PO 4a	PO 4b	PO 4c	PO 5a	PO 5b	PO 6	PO 7a	PO 7b	PSO 1	PSO 2	PSO 3
CS2114.1	2	1	2	2	2		1	2		1		2				1		
CS2114.2	2		1	1		2		2		2				2		1		2
CS2114.3	1					1		2		2	1	2	2		1	1		2
CS2114.4	2		1	1		3	3	2			2			1			1	3
CS2114.5	2	1							1		1		2			1	2	3
CS2114.6	2				1		2	1	2	1	1		1			3	2	3
CS2114.7	1						3	3	3	2	2	3		2	2	1	3	2
CS2114.8		2	2		2	3	2	2	1		3	2			1	3	3	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Course Title and Code: Applied Advanced Machine Learning CS2115	
Hours per Week	**L-T-P: 3-0-4**
Credits	**5**
Students who can take	M.Tech. II Sem

Course Objective-

The course, Advanced Applied Machine Learning, offered for M.Tech students aims to develop deeper understanding of machine learning and its applications focusing on in-depth coverage of new and advanced methods in machine learning, as well as their underlying theory. It emphasizes approaches with practical relevance and discusses a number of recent applications of machine learning in areas like information retrieval, recommender systems, data mining, computer vision, natural language processing and robotics. An open research project is a major part of the course.

Course Outcome:

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

CS2115.1. Analyse the loss function and their convergence in various machine learning algorithms.

CS2115.2. Apply important problem-solving techniques like, Stochastic Gradient Descent, Backpropagation, Duality and Regularization in practical applications.

CS2115.3. Demonstrate expertise in Deep Learning, Ensemble Learning and Reinforcement Learning.

CS2115.4. Explore text and image data along with regular tables and graphs.

CS2115.5. Implement a real-life project using Machine Learning techniques.

Prerequisites		**Basic Machine learning, Linear algebra, Probability, Statistics, Python programming**
Sr. No	**Specifications**	**Marks**
01	Attendance	Nil
02	Assignments	20
03	Class Participation	Nil
04	Quiz (2)	10
05	Theory Exam	Nil
06	Theory Exam (Mid)	20
07	Theory Exam (Final)	20
08	Report-1	Nil
09	Report-2	Nil
10	Report	Nil
11	Project-1	10
12	Project-2	Nil
13	Project-3	Nil
14	Lab Evaluation (Mid)	10
15	Lab Evaluation (Final)	10
16	Course portfolio	Nil
	Total (100)	**100**

Retest

1	Quiz	20
2	Theory Exam (Final)	20

Syllabus (Theory)

1 **Introduction:** ML concepts
2 **Stochastic gradient descent:** Error Bounds, Random Forest, Naive Bayes and its convergence
3 **Perceptron Learning:** Learnability, VC dimensions, Occam's Razor Principles, Logistic Regression.
4 **Kernel tricks and regularizations:** Support vector machines (Quadratic optimization), Dual support vector machines.
5 **Backpropagation:** Neural Networks and its accuracies, Convolutional neural networks, Recurrent neural networks.
6 **Graphical models:** Expectation maximization, Bayesian network analysis.
7 **Structure Learning**: Principal components analysis, Clustering (Convergence and Initialization), Ranking
8 **Ensemble Learning:** Bagging, Boosting and Stacking
9 **Online learning**: Markov decision, k-arm Bandit, Reinforcement learning, DeepRL

Syllabus (Practical)

1. Write Python program to implement: stochastic gradient descent (SDG), overfitting, regularization, momentum, kernel learning, convergence, parameter optimization, learning rate and sparse matrix multiplication in standard ML algorithms and explore the efficiency.
2. Implement graphical models listed above.
3. Write program for PCA, K-Means and PageRank.
4. Write python program for ensemble learning algorithms.
5. Implement online learning algorithms.

Text Books:

1. Kevin P. Murphy, Machine Learning – A Probabilistic Perspective, MIT Press, 2012.
2. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.
3. Hastie, Tibshirani, Friedman, "The Elements of Statistical Learning", Springer, 2001.
4. Vapnik, "Statistical Learning Theory", Wiley, 1998.
5. Tom Mitchell, "Machine Learning", McGraw Hill, 1997.

Reference Courses:

1. Advance Machine Learning CS6780 - Advanced Machine Learning. Spring 2019. Prof. Thorsten Joachims Cornell University. https://www.cs.cornell.edu/courses/cs6780/2019sp/
2. Machine Learning by Andrew NG. https://www.coursera.org/learn/machine-learning

Reference Materials:

1. Tong Zheng. Solving large scale linear prediction problems using stochastic gradient descent algorithms. Proceedings of the International Conference on Machine Learning (ICML), 2004.
2. Martin Abadi et al. TensorFlow: Large-Scale Machine Learning on Heterogeneous Distributed Systems. Preliminary White Paper, 2015. Since this is a white paper and is a bit longer than what we'll usually be reading, we will cover Sections 1, 2, 4.1, 6, and 9 only.

3. Rich Caruana, Steve Lawrence, and C Lee Giles. Overfitting in neural nets: Backpropagation, conjugate gradient, and early stopping. In Advances in Neural Information Processing Systems (NeurIPS), 2001.
4. Sergey Ioffe, Christian Szegedy. Batch Normalization: Accelerating Deep Network Training by Reducing Internal Covariate Shift. Proceedings of the International Conference on Machine Learning (ICML), 2015.
5. Ilya Sutskever, James Martens, George Dahl, and Geoffrey Hinton. On the importance of initialization and momentum in deep learning. Proceedings of the International Conference on Machine Learning (ICML), 2013.
6. Suyog Gupta, Ankur Agrawal, Kailash Gopalakrishnan, and Pritish Narayanan. Deep learning with limited numerical precision. Proceedings of the International Conference on Machine Learning (ICML), 2015.

Course Articulation Matrix: (Mapping of COs with POs)

Course Outcome	Correlation with program outcomes															Correlation with program specific outcomes		
	PO 1	PO 2a	PO 2b	PO 2c	PO 3a	PO 3b	PO 3c	PO 4a	PO 4b	PO 4c	PO 5a	PO 5b	PO 6	PO 7a	PO 7b	PSO-1	PSO-2	PSO-3
CS2115.1	1							1	1	1						2	1	2
CS2115.2	1				1	1	1	1	2	1						1	1	2
CS2115.3	1	1	1		1	1	1	1	2	1						1	1	2
CS2115.4	1			1	1	1	1	1	2	1						1	1	2
CS2115.5	1		1	1	1	1	1	1	2	1						1	1	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Course Title and Code: Project-II PR2102	
Prerequisites	**Nil**
Hours per Week	**L-T-P: 2-0-0**
Credits	**02**
Students who can take	**M.Tech. Semester II**

Course Objective: The course aims to equip students with knowledge of the nuances of building a project utilizing the concepts either attained in undergraduate or in parallel being attained in Sem I. The course includes basics of preparation of project proposal, project creation and management cycle, team work, converting into a usable application and test cases to evaluate the project and preparation of report of project.

Course Outcome

PR2102.1. Identify project goals, constraints, deliverables, performance criteria, control needs, and resource requirements to serve requirement

PR2102.2. Implement project management knowledge, processes, lifecycle and the embodied concepts, tools and techniques in order to achieve project success

PR2102.3. Utilize technology tools for communication, collaboration, information management, and decision support

PR2102.4. Apply appropriate legal and ethical standards.

PR2102.5. Test the Project with varied test cases.

Evaluation Scheme:

Sr. No	**Specifications**	**Marks**
01	Attendance	NIL
02	Assignment	NIL
03	Class Participation	30
04	Quiz	NIL
05	Theory Exam (Mid Term)	NIL
06	Theory Exam	NIL
07	Theory Exam (Final)	NIL
08	Report-1	10
09	Report-2	20
10	Report-3	NIL
11	Project -1	40
12	Project -2	NIL
13	Project -3	NIL
14	Lab Evaluation – I	NIL
15	Lab Evaluation – II	NIL
16	Course portfolio	NIL
	Total (100)	**100**

CO	CORRELATION WITH PROGRAM OUTCOMES															CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
	PO 1	PO 2a	PO 2b	PO 2c	PO 3a	PO 3b	PO 3c	PO 4a	PO 4b	PO 4c	PO 5a	PO 5b	PO 6	PO 7a	PO 7b	PSO 1	PSO 2	PSO 3
PR2102.1	1				1			1			1					1	1	1
PR2102.2					1			1		1		1				1	1	1
PR2102.3						1		1	1	1		1				1	1	1
PR2102.4			1			1	1		1	1	1			1				
PR2102.5	1					1	1		1	1	1	1			1	1	1	1

Course Title and Code: Critical Thinking for Decisions at Workplace | CC2114

Course Objective:

The modern world offers confounding opinions and choices that need to be navigated judiciously. This course explores frameworks and processes to critically examine narratives, reconstruct them, and craft well-reasoned stories that can be told using impactful communication.

Learning Outcomes:

The students will be able to:

CC2114.1. Formulate intelligent questions to investigate.

CC2114.2. Evaluate information and argument for correctness, consistency, relevance and validity.

CC2114.3. Compose well-structured and well-reasoned arguments.

CC2114.4. Articulate and evaluate the impact of narratives.

CC2114.5. Distinguish between facts, assumptions and opinion.

Prerequisites	**N/A**
Hours per Week	**L-T-P: 2-1-0**
Credits	**2**

Sr. No	**Specifications**	**Weightage**
01	Attendance	Nil
02	**Assignment**	**40**
03	**Class Participation**	**20**
04	**Quiz**	**20**
05	Theory Exam	Nil
06	Theory Exam	Nil
07	**Theory Exam (3)**	**20**
08	Report-1	Nil
09	Report-2	Nil
10	Report-3	Nil
11	Project -1	Nil
12	Project -2	Nil
13	Project -3	Nil
14	Lab Evaluation	Nil
15	Lab Evaluation	Nil
16	Course portfolio	Nil
	Total (100)	**100**

Evaluation scheme for re-test

7	Theory Exam	20

Syllabus

I. **Introduction to Critical Thinking**- Definitions of Critical Thinking, its applications and the methods to think critically. Paul & Elder model will be used.

II. **Importance of questioning**-The key to critical thinking is the ability to formulate intelligent questions. Students will be able to create, improve and prioritize their questions. They will be able to use different types of question by using Bloom's taxonomy to understand the root of any situation, problem or subject.

III. **Examine data Critically-**Students will be able to filter information, separate fact from opinion, identify cognitive biases and become aware of the ladder of inference. They will also be taught to conduct responsible research and basics of bibliography and citation.

IV. **Construct and reconstruct argument-** Students will be taught to construct arguments with sound reasoning. They will be able to support their claims and opinions with compelling data and facts, and present well-informed arguments. Evaluate argument using logical fallacies.

V. **Building a compelling Narrative-** Stories that we create and narrate influence how we see ourselves and our association with others. The students will be able to observe, think, create and narrate their stories in an effective manner.

Text Books and Reference Books

Critical thinking: an introduction
Alec Fisher - Cambridge University Press - 2011
Critical thinking its definition and assessment
Alec Fisher-Michael Scriven - Centre for Research in Critical Thinking - 1997
Art of thinking clearly
Rolf Dobelli - Harper Collins Usa – 2014
Critical thinking skills: developing effective analysis and argument
Stella Cottrell - Palgrave Macmillan – 2017
Thinking, fast and slow
Daniel Kahneman - Farrar, Straus and Giroux - 2015

CO		CORRELATION WITH PROGRAM OUTCOMES														CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
	PO 1	PO 2a	PO 2b	PO 2c	PO 3a	PO 3b	PO 3c	PO 4a	PO 4b	PO 4c	PO 5a	PO 5b	PO 6	PO 7a	PO 7b	PSO 1	PSO 2	PSO 3
CC2114.1	1		1					1	1		1		1	1				
CC2114.2	1			1					1		1	1	1	1				
CC2114.3	1		1	1				1	1		1	1	1	1				
CC2114.4	1			1					1		1	1	1	1				
CC2114.5	1		1					1	1		1		1	1				

Course code	Course Title	Teaching Scheme	
		L T P	Credits
EE2201	Computer Vision	3 0 2	4

Course Objectives: This course aims to develop skills for building computer vision applications with Python, OpenCV, and Deep Learning.

Learning Outcomes:

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

EE2201.1. Implement Image Processing Algorithms using OpenCV tools.

EE2201.2. Use supervised and unsupervised machine learning algorithms for image classification.

EE2201.3. Design, Train and Test Neural Networks and deploy suitable activation functions image processing function using Keras/Tensorflow libraries.

EE2201.4. Identify suitable Performance Parameters and evaluate valuate technique for best performance.

Assessment Scheme:

Sr. No.	Evaluation Component	Marks
1	Attendance	Nil
2	Assignment	20
3	Class Participation	Nil
4	Quiz	20
5	Theory Exam-I	Nil
6	Theory Exam-II	Nil
7	Theory Exam-III	30
8	Report I	Included with Project
9	Report II	Nil
10	Report III	Nil
11	Project I	Nil
121	Project II	Nil
13	Project III	30
14	Lab Evaluation I	Nil
15	Lab Evaluation II	Nil
16	Course Portfolio	Nil
	Total (100)	100
Evaluation Scheme for Re-Test		
1	**Theory Exam - III**	30
	Total (30)	30

Syllabus:

Module 1: Introduction to Image Processing System-Image Sampling, Quantization, Thresholding, Image Enhancement, Contrast Stretching- Linear, Logarithmic, Power Law, Image Histograms-Histogram Equalization, Histogram Processing, Filters-Median, Min, max, Nonlinear Filters-Smoothing /Weighted Smoothing, Image Sharpening. Edge Detection and Segmentation

Module 2: Deep Learning for Computer Vision, Image Classification and Segmentation using Machine Learning, Understanding Neurons, Activation functions, Gradient Descent and Backpropagation in neural Networks, Building a Neural Network Model for Classification problems, Limitations of Neural Networks.

Module 3: Convolutional Neural Networks, Keras Basics, CNN architecture-Convolution, Pooling and Fully

connected layers.

References:

1. Digital Image Processing- S Jayaraman, S Esakkirajan, T Veerakumar
2. Introduction to Statistical Learning-Garet James
3. Deep Learning book by Ian Goodfellow, Yoshua Bengio, and Aaron Courville.

Web resource:

https://github.com/machine-perception-robotics-group/GoogleColabNotebooks/tree/eng1/MLDL_lecture_notebooks
https://www.tensorflow.org/api_docs/python/tf/keras/layers/Dense
https://www.tensorflow.org/api_docs/python/tf/keras/initializers

Course Articulation Matrix: (Mapping of COs with POs)

CO		CORRELATION WITH PROGRAM OUTCOMES														CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
	PO 1	PO 2a	PO 2b	PO 2c	PO 3a	PO 3b	PO 3c	PO 4a	PO 4b	PO 4c	PO 5a	PO 5b	PO 6	PO 7a	PO 7b	PSO 1	PSO 2	PSO 3
EE2201.1					2									1				
EE2201.2	1					2								1				
EE2201.3	1					2				3								
EE2201.4							2	1		3								

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Course Title and Code: Internship (PS2101)		
Total Duration	6-8 Weeks	
Credits	**04**	
Students who can take	M.Tech Semester-III (Batch: 2019-2021) **Core**	
Course Objective: The purpose of the internship is to give students the opportunity to develop an understanding of their profession in a professional context.		
Course Outcome: After course completion, the student will be able to: **PS2101.1** Identify skills and capabilities that intersect effectively with the needs of industry. **PS2101.2** Apply and practice good communication skills in the workplace setting. **PS2101.3** Reflect and evaluate on experiences that might lead to future employment.		
Evaluation Scheme:		
Supervisor Evaluation	**Evaluation Component**	**Marks**
External Supervisor	Day to Day task Record, External supervisor feedback form	50
Faculty Supervisor	Reporting Activity Fortnightly, Presentation &Viva	30
	Report	20
	Total	**100**

Course Articulation Matrix: (Mapping of COs with POs)

CO		CORRELATION WITH PROGRAM OUTCOMES														CORRELATION WITH PROGRAM SPECIFIC OUTCOMES			
	PO 1	PO 2a	PO 2b	PO 2c	PO 3a	PO 3b	PO 3c	PO 4a	PO 4b	PO 4c	PO 5a	PO 5b	PO 6	PO 7a	PO 7b	PSO 1	PSO 2	PSO 3	PSO 4
PS2101.1	2		2		3	3	1	3			3			1		2			
PS2101.2		2			2						2		3				2		2
PS2101.3	2		2	2	2	2	2				3	3						2	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Course Title and Code: Industrial Project-I (PR2104)	
Hours per Week	**Minimum 20 hrs. per week for full semester.**
Credits	**10**
Students who can take	M.Tech Semester-III (Batch: 2020-2022) **Core**

Course Objective:
The purpose of the Industrial Project-I is to give students the opportunity to develop an understanding of their profession in a professional context. They will prepare a research, development, or other type of engineering project with the guidance of an industrial and academic supervisors.

After course completion, the student will be able to:
PR2104.1 Identify skills and capabilities that intersect effectively with the needs of industry.
PR2104.2 Apply and practice good communication skills in the workplace setting.
PR2104.3 Reflect and evaluate on experiences that might lead to future employment.
PR2104.4 Report research findings in written and verbal forms.
PR2104.5 Demonstrate and apply industry observation/research skills to complete a project.

Evaluation Scheme: Weightages of different evaluation components

Mid-Term		
Expert Evaluation	**Evaluation Component**	**Marks**
Panel of Examiner	Synopsis	15
Panel of Examiner	Report Content & Presentation	15
Internal Mentor	Reporting Activity Fortnightly	10
Industry Expert	Industry Expert Feedback	15
M.Tech Coordinator	M.Tech Coordinator Feedback	5
	Total	**60**
Final Term		
Industry Expert	Industry Feedback	50
Internal Mentor	Reporting Activity Fortnightly	20
Panel of Examiner	Presentation, Report, Viva	60
M.Tech Coordinator	M.Tech Coordinator Feedback	10
	Total	**140**
	Total (Mid-term Final Term)	**200**

CO		CORRELATION WITH PROGRAM OUTCOMES														CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
	PO 1	PO 2a	PO 2b	PO 2c	PO 3a	PO 3b	PO 3c	PO 4a	PO 4b	PO 4c	PO 5a	PO 5b	PO 6	PO 7a	PO 7b	PSO 1	PSO 2	PSO 3
PR2104.1	2		2		3	3	1	3			3			1		2		
PR2104.2		2			2						2		3				2	
PR2104.3	2		2	2	2	2	2				3	3						2
PR2104.4		3		3	3		1				2		2	3	2			2
PR2104.5	2			3	3	2					3			3	3	2		

Course Articulation Matrix: (Mapping of COs with POs)

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Course Title and Code:	**Natural Language Processing; CS2203**
Hours per Week	**L-T-P: 3-0-2**
Credits	**4**
Students who can take	B. Tech. Semester VII

Course Objective- This course will cover the latest advances in natural language processing, primarily through the applications of deep learning using programming in Python and Tensorflow/Keras and/or PyTorch. It will cover basics of natural language processing through word vector representations, language models for neural machine translation and various other tasks like summarization, question answering, chatbots, etc.

Course Outcome:

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

CS2203.1. Analyze how words are represented as vectors for natural language processing.
CS2203.2. Model NLP problems using tools from calculus, linear algebra and probability.
CS2203.3. Design RNNs for various NLP tasks like machine translation.
CS2203.4. Design transformer and BERT models for various NLP tasks.
CS2203.5. Design and analyze their own algorithms and implement them using Tensorflow/Keras or PyTorch.

Evaluation Scheme		
Sr. No	**Specifications**	**Marks**
01	Attendance	Nil
02	Assignment	20
03	Class Participation	Nil
04	Quiz	Nil
05	Theory Exam-I	Nil
06	Theory Exam-II	10
07	Theory Exam-III	20
08	Report-I	10
09	Report-II	Nil
10	Report-III	Nil
11	Project-I	15
12	Project-II	Nil
13	Project-III	Nil
14	Lab Evaluation-I (Continuous)	15
15	Lab Evaluation-II (Test)	10
16	Course Portfolio	Nil
	Total (100)	**100**

Retest

1	Theory Exam-III	20
2	Lab Evaluation-II	10
	Total	**30**

Syllabus (Theory):

UNIT – I: Review

Basics related to Calculus, Linear Algebra, probability, optimization for deep learning.

UNIT – II: Basics of Deep Learning

Simple and advanced word vector representations: word2vec and GloVe. Softmax and single layer neural networks. Deep neural networks and backpropagation, overfitting, regularization, activation functions. Introduction to Tensorflow/Keras and PyTorch.

UNIT – III: Recurrent Neural Networks

Recurrent Neural Networks for natural language processing, Seq2Seq and Large-scale deep learning, GRUs and LSTMs. Implementations using Tensorflow/Keras and PyTorch.

UNIT – IV: Advanced Architectures for NLP

Transformers and BERT model for language translation and question answering and their implementations, chatbots, etc. Discussion on the future of natural language processing using deep learning.

Text Books:

There is no text book for the course. However, we will closely follow the following course taught at Stanford University.

1. CS224n: Natural Language Processing with Deep Learning

Reference Books/Courses:

1. Ian Goodfellow and Yoshua Bengio and Aaron Courville, "Deep Learning", MIT Press. Online available at http://www.deeplearningbook.org/
2. Stanford CS230: Deep Learning
3. Coursera specialization on Deep Learning
4. Coursera Specialization on Natural Language Processing
5. Speech and Language Processing (3rd ed. draft)
6. Transactions of the Association for Computational Linguistics

	PO1	PO2a	PO2b	PO2c	PO3a	PO3b	PO3c	PO4a	PO4b	PO4c	PO5a	PO5b	PO6	PO7a	PO7b	PSO1	PSO2	PSO3
CS2203.1	1				2		2	2	2	2				1	1	2		
CS2203.2					2		2		1	1	2						1	1
CS2203.3				1		2		2	1	1	2	1				1	2	1
CS2203.4	1			2		2		2	2	1	1	1				1	2	2
CS2203.5	2					2	2	2	2	2	2	2		2	2	1		3

Course Title and Code: **CS2201: Large Scale Graph Analytics**	
Hours per Week	**L-T-P: 3-0-2**
Credits	**4**
Students who can take	M.Tech Sem III

Course Objective-

Graphs are a universal construct to deal with the complex data in science, nature, and technology. With the emergence of large online social networks and broad availability of network data in various domains, real-world networks pose unprecedented challenges. This course focuses on analysis of large-scale graphs and introduces recent advances in the area.

Course Outcome:

On successful completion of this course, the students will be able to

CS2201.1. Analyze the concept of small world graph, Power law distribution, Centrality measures, Communities, modularity of large-scale graph.

CS2201.2. Compute the ranking graph nodes using HITS and PageRank

CS2201.3. Identify and apply the Motifs, Contagions, Viral propagations

CS2201.4. Demonstrate Graph Learning and GPU computations

CS2201.5. Experiment using libraries like, NetworkX, SNAPPY and GIRAPH

Prerequisites		**Programming**
Sr. No	**Specifications**	**Marks**
01	Attendance	Nil
02	Assignments	20
03	Class Participation	Nil
04	Quiz	Nil
05	Theory Exam-I	Nil
06	Theory Exam-II	20
07	Theory Exam-III	20
08	Report-I	Nil
09	Report-II	Nil
10	Report-III	Nil
11	Project-I	20
12	Project-II	Nil
13	Project-III	Nil
14	Lab Evaluation-I (Test)	10
15	Lab Evaluation-II (Test)	10
16	Course portfolio	Nil
	Total (100)	**100**

Retest

1	Lab Evaluation-II	10
2	Theory Exam-III	20
	Total	30

Syllabus

1: Introduction

General introduction to real-world networks, interdisciplinary network science field and why computer science matters in that context, review on fundamental concepts in graph theory, overview of linear algebra and matrix operations.

2: PageRank

Link analysis in networks, hubs and authorities, HITS algorithm, degree-driven metrics to determine important nodes and edges, use of PageRank in web and beyond.

3: Graph Traversal and Maximum Flow
Fundamental and practical algorithms for graph traversal, breadth-first search, depth-first search, strongly connected components, direction-optimizing BFS, maximum flows & minimum cuts.

4: Shortest Paths and Centrality
Single-source shortest paths, all-pairs shortest paths, practical algorithms for Katz, eigenvector, closeness, and betweenness centrality computations, adaptations for weighted graphs.

5: Community Detection
Graph clustering problem, community definition and detection algorithms, evaluation metrics, modularity, graph conductance, types of communities in real-world networks, overlapping communities.

6: Dense Subgraphs
Densest subgraph problem, dense subgraph models and measures, clique and quasi-cliques, connections to graph clustering and community detection, use of higher-order structures, core, truss, and nucleus decompositions.

7: Graph Partitioning
Definition of graph partitioning, applications in scientific computing and data mining, sparse matrix vector multiplication, Kernighan-Lin algorithm, load balancing, multi-level methods, streaming graph partitioning.

8: Network Motifs
Subgraph patterns, mesoscale structures, triangles and higher-order structures, motif distributions per node/edge, adaptation for directed networks, motifs on bipartite graphs and limitations, connections to subgraph isomorphism.

9: Heterogeneous and Non-traditional Networks
Directed networks and challenges, graphs with categorical and numerical node/edge labels, bipartite networks and challenges, k-partite networks and applications.

10: Temporal Graphs I.
Temporal walks, paths, and reachability, basic graph metrics in temporal graphs such as subgraphs, connectivity, and centrality, models of temporal networks, temporal network motifs. Streaming models for graph algorithms, graph sketches, incremental methods to maintain graph analytics such as centrality, community detection, pagerank, and k-core computation.

11: Machine (and Deep) Learning on Graph.
Representation learning on graphs, applications in downstream ML tasks, embedding nodes, embedding subgraphs, bipartite graph embeddings, graph neural networks.

12: Parallel Graph Analytics.
Shared-memory graph processing frameworks, GPU algorithms and frameworks for graph processing, Distributed-memory graph processing frameworks, vertex-programming model, specialized distributed graph algorithms (graph coloring, centrality, k-core computation), connections to the graph partitioning.

Text Books:

1. Networks, Crowds, and Markets, by D. Easley & J. Kleinberg.
2. Networks An Introduction, by M.E.J. Newman.

Reference Courses:

1. Networks (Daron Acemoglu and Asu Ozdaglar, MIT)
2. Analysis of Networks (Jure Leskovec, Stanford)
3. Networks (David Easley and Jon Kleinberg, Cornell)
4. Topics in Social Data (Johan Ugander, Stanford)
5. Network Theory (Mark Newman, University of Michigan)
6. Graphs and Networks (Dan Spielman, Yale)
7. Statistical Network Analysis (Jennifer Neville, Purdue)
8. Network Analysis and Modeling (Aaron Clauset, Sante Fe Institute)
9. Parallel Graph Analysis (George Slota, RPI)
10. Large-Scale Graph Mining (A. Erdem Sariyuce, University of Buffalo)
11. Mining Large-scale Graph Data (Danai Koutra, University of Michigan)
12. Data Mining meets Graph Mining (Leman Akoglu, Stony Brook)
13. Graphs and Networks (Charalampos Tsourakakis, Aalto University)
14. Large-Scale Graph Processing (Keval Vora, Simon Fraser University)

Course Articulation Matrix: (Mapping of COs with POs)

Course Outcome	Correlation with program outcomes															Correlation with program specific outcomes		
	PO 1	PO 2a	PO 2b	PO 2c	PO 3a	PO 3b	PO 3c	PO 4a	PO 4b	PO 4c	PO 5a	PO 5b	PO 6	PO 7a	PO 7b	PSO-1	PSO-2	PSO-3
CS2201.1	2							1	1	1						2	2	2
CS2201.2	2				1	1	1	1	2	1						2	2	2
CS2201.3	2	2	2		2	1	1	1	2	1						2	2	2
CS2201.4	2			2	2	2	1	2	2	3						2	2	3
CS2201.5	2		2	2	1	2	2	2	2	2						2	2	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Course Title and Code: Industrial Project-II (**PR2107)**	
Hours per Week	4 to 6 Months
Credits	**16**
Students who can take	M.Tech Semester-IV (Batch: 2019-2021) **Core**

Course Objective:

The purpose of the Industry Project is to give students the opportunity to gain an insight into the operation of their field of study and develop an understanding of their profession in a professional context. By enabling students to observe the day-to-day operations of an organization and to prepare a research project based on these observations, with the guidance of a work place and academic supervisor, students will develop a critical perspective of their profession. Students will attend pre and post placement classes to guide the development of their research project, the sourcing of their host organization and the protocols associated with the placement.

Course Outcomes: At the end of the course, students will be able to

[PR2104.1]. Identify skills and capabilities that intersect effectively with the needs of industry.
[PR2104.2]. Apply and practice good communication skills in the workplace setting.
[PR2104.3]. Reflect and evaluate on experiences that might lead to future employment.
[PR2104.4]. Report research findings in written and verbal forms.
[PR2104.5]. Demonstrate and apply research skills to complete a project.

Evaluation Scheme:

Expert Evaluation	**Evaluation Component**	**Mid-Term**	**Final Term**
Industry Expert	Industry Expert Feedback	15	50
Panel of Examiner	Synopsis	15	NA
	Report Content & Presentation	15	60
Internal Mentor	Reporting Activity Fortnightly	10	20
IP-II Coordinator	IP-2 Coordinator Feedback	5	10
Total		**60**	**140**

Course Syllabi:

Dissertation-II/ Industrial Project-II/Entrepreneurial Project-II - The students who work on a project are expected to work towards the goals and milestones set in Dissertation-II / Industrial Project-II/ Entrepreneurial Project-II. The problem can be extension of Dissertation-I/ Industrial Project-I /Entrepreneurial Project-I or a new problem. The student will submit a synopsis at the beginning of the semester for approval from the departmental committee in a specified format. At the end there would be a demonstration of the solution and possible future work on the same problem. The student will have to present the progress of the work through seminars and progress reports.

Operation Procedure

- Student has to devote full semester for Dissertation/Industrial Project/Entrepreneurial Project.
- Student has to report to the Supervisor regularly.
- Dissertation-II/ Industrial Project-II/Entrepreneurial Project-II evaluation has to be carried out in the presence of a two member Committee comprising.
- Experts in the relevant area constituted by the Supervisor.
- Final Seminar Report to be submitted has to be in formal hard bound cover bearing of the Institute emblem.

Reference Books and Tools:

Based on literature survey to be done with peer reviewed journals and magazines and relevant tools required to build the project.

Course Articulation Matrix: (Mapping of COs with POs)

Course Outcome	CORRELATION WITH PROGRAM OUTCOMES															CORRELATION WITH PROGRAM SPECIFIC OUTCOMES			
	PO 1	PO 2a	PO 2b	PO 2c	PO 3a	PO 3b	PO 3c	PO 4a	PO 4b	PO 4c	PO 5a	PO 5b	PO 6	PO 7a	PO 7b	PSO 1	PSO 2	PSO 3	PSO 4
PR2104.1	2		2		3	3	1	3			3			1		2			
PR2104.2		2			2						2		3				2		3
PR2104.3	2		2	2	2	2	2				3	3						2	
PR2104.4		3		3	3		1				1		2	2	2			2	2
PR2104.5	2			3	3	2					3			2	3	2			3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Program Articulation Matrix - (M. Tech DS) Batch 2020-22

S.No.	Course	Course Title	Credit	Year	Semester	PO1	PO2a	PO2b	PO2c	PO3a	PO3b	PO3c	PO4a	PO4b	PO4c	PO5a	PO5b	PO6	PO7a	PO7b	PSO1	PSO2	PSO3
1	AS2101	Statistical Data Analysis	5	1	1	0.67	0	0	0	0.67	0	0.67	0	0	0	0	0	0.67	0.67	0	0	0	0
2	CS2101	Cloud based Big Data System-I	4	1	1	1.63	0.38	0.38	0.88	0.75	1.38	0.75	1.5	0.63	1.25	1.13	1.13	0.5	1	1.25	1.5	1.5	2.38
3	CS2102	Machine Learning and Data Mining	5	1	1	0.8	0	0	0.75	1	1.5	1.75	1.75	1.5	2	1.5	1	0	1	0.75	1.5	1.25	1.5
4	CS2103	Robotic Process Automation and Applications	5	1	1	0.5	0.33	0.33	0	0.67	0.17	0.33	0.33	0	0.5	0.33	0	0.5	0.83	0	2.33	2.83	2
5	PR2101	Project-I	2	1	1	0.71	0.33	0	0	0.33	0	0.33	0.5	0.83	1	0	0.33	0.33	0.33	0.33	0.33	0.5	0.83
6	CC2171	Critical Thinking for Developing Perspectives	2	1	1	1	0	0.3	0.1	0	0	0.2	0.5	0.1	0.1	0.2	0	0.1	0	0.1	0	0	
7	AS2104	Statistical Data Analysis-II	5	1	2	0.5	0	0.75	0	0.25	0.5	0	1	0.25	1	0	0	0	0.25	0	0	0.25	0.25
8	CS2114	Cloud based Big Data System-II	4	1	2	1.5	0.5	0.75	0.5	0.63	1.13	1.38	1.75	0.88	1	1.25	1.13	0.63	0.63	0.5	1.38	1.38	2.25
9	CS2115	Applied Advanced Machine Learning	5	1	2	1	0.2	0.4	0.4	0.8	0.8	1	1.8	1	0	0	0	0	0	0	1.2	1	2
10	EE2201	Computer Vision	4	1	2	0.25	0	0	0	0.5	0	0.25	0	0.5	0.25	0	0.25	0	0.25	0.25	1.25	1.25	1
11	PR2102	Project-II	2	1	2	0.71	0.33	0	0	0.33	0	0.33	0.5	0.83	1	0	0.33	0.33	0.33	0.33	0.33	0.5	0.83
12	CC2114	Critical Thinking for Decisions at Workplace	2	1	2	0.8	0	0.3	0.2	0	0	0.2	0.3	0.4	0.1	0.3	0	0.3	0.1	0	0	0	0
13	CS2111	Natural Language Processing	4	2	3	1	0	0	0.75	1	1.5	1.5	2	2	1.75	1.75	1	0	0.75	0.75	1.25	1.25	1.75
14	CS2201	Large Scale Graph Analytics	4	2	3	2	0.4	0.8	0.8	1.2	1.2	1	1.4	1.8	1.6	0	0	0	0	0	2	2	2.4
15	PR2104	Industrial Project-I	10	2	3	1.2	1	0.8	1.6	2.6	1.4	0.8	0.6	0	0	2.6	0.6	1	1.4	1	0.8	0.4	0.8
16	PR2107	Industrial Project-II	16	2	3	1.2	1	0.8	1.6	2.6	1.4	0.8	0.6	0	0	2.4	0.6	1	1	1	0.8	0.4	0.8
					Total	14.9	4.475	6.013	7.908	14.8	12.85	12.77	15.91	12.1	12.84	12.34	6.914	5.03	8.946	6.671	17.01	16.34	17.96
	Desired Competence Level (N - Novice, AB - Advanced Beginner, C - Competent)					C	N	N	N	C	AB	AB	C	C	C	AB	AB	AB	AB	N	C	C	C

Note:
The above-mentioned contributions of the already taught flexicore/emerging tech and department elective courses is the minimum contribution out of multiple options given to students.
Contribution of courses to be taught is specified as minimum expected contribution.
Open Electives, Practice School 1 and Practice School 2 are excluded from above calculation and their contribution towards attainment of PO and PSO is in addition.
* TBD: To be decided.