PRESIDENCY UNIVERSITY

Presidency University Act, 2013 of the Karnataka Act No. 41 of 2013 | Established under Section 2(f) of UGC Act, 1956

Approved by AICTE, New Delhi

PRESIDENCY SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

Program Regulations and Curriculum

2025-2027

MASTER OF TECHNOLOGY (M.Tech.) in

COMPUTER SCIENCE AND ENGINEERING

Specialization in

Data Science

based on Choice Based Credit System (CBCS) and Outcome Based Education (OBE)

(As amended up to the xx Meeting of the Academic Council held on xx June 2025. This document supersedes all previous guidelines)

Regulations No: PU/AC-xx.x/SOCSE06/DSC/2025-2027

Resolution No.xx of the xx Meeting of the Academic Council held on xx June 2025, and ratified by the Board of Management in its x Meeting held on xx June 2025.

JUNE-2025

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PART A – PROGRAM REGULATIONS

1. Vision & Mission of the University and the School / Department

1.1 Vision of the University

To be a Value-driven Global University, excelling beyond peers and creating professionals of integrity and character, having concern and care for society.

1.2 Mission of the University

- Commit to be an innovative and inclusive institution by seeking excellence in teaching, research and knowledge-transfer.
- Pursue Research and Development and its dissemination to the community, at large.
- Create, sustain and apply learning in an interdisciplinary environment with consideration for ethical, ecological and economic aspects of nation building.
- Provide knowledge-based technological support and services to the industry in its growth and development.
- To impart globally-applicable skill-sets to students through flexible course offerings and support industry's requirement and inculcate a spirit of new-venture creation.

1.3 Vision of Presidency School of Computer Science and Engineering

To be a value-based, practice-driven Presidency School of Computer Science and Engineering, committed to developing globally competent engineers, dedicated to developing cutting-edge technology to enhance the quality of life.

1.4 Mission of Presidency School of Computer Science and Engineering

- Cultivate a practice-driven environment with computing-based pedagogy, integrating theory and practice.
- Attract and nurture world-class faculty to excel in teaching and research in the realm of computing sciences.
- Establish state-of-the-art computing facilities for effective teaching and learning experiences.
- Promote interdisciplinary studies to nurture talent for global impact.
- Instill entrepreneurial and leadership skills to address social, environmental and community needs.

2. Preamble to the Program Regulations and Curriculum

This is the subset of Academic Regulations and it is to be followed as a requirement for the award of M.Tech degree.

The Curriculum is designed to take into the factors listed in the Choice Based Credit System (CBCS) with focus on Social Project Based Learning, Industrial Training, and Internship to enable the students to become eligible and fully equipped for employment in industries, choose higher studies or entrepreneurship.

In exercise of the powers conferred by and in discharge of duties assigned under the relevant provision(s) of the Act, Statutes and Academic Regulations of the University, the Academic Council hereby makes the following Regulations.

3. Short Title and Applicability

a. These Regulations shall be called the Master of Technology Degree Program Regulations and Curriculum 2025-2027.
b. These Regulations are subject to, and pursuant to the Academic Regulations.
c. These Regulations shall be applicable to the ongoing Master of Technology Degree Programs of the 2025-2027 batch, and to all other Master of Technology Degree Programs which may be introduced in future.
d. These Regulations shall supersede all the earlier Master of Technology Degree Program Regulations and Curriculum, along with all the amendments thereto.
e. These Regulations shall come into force from the Academic Year 2024-2025.

4. Definitions

In these Regulations, unless the context otherwise requires:

a. *"Academic Calendar" means the schedule of academic and miscellaneous events as approved by the Vice Chancellor;*

b. *"Academic Council" means the Academic Council of the University;*

c. *"Academic Regulations" means the Academic Regulations, of the University;*

d. *"Academic Term" means a Semester or Summer Term;*

e. *"Act" means the Presidency University Act, 2013;*

f. *"AICTE" means All India Council for Technical Education;*

g. *"Basket" means a group of courses bundled together based on the nature/type of the course;*

h. *"BOE" means the Board of Examinations of the University;*

i. *"BOG" means the Board of Governors of the University;*

j. *"BOM" means the Board of Management of the University;*

k. *"BOS" means the Board of Studies of a particular Department/Program of Study of the University;*

l. *"CGPA" means Cumulative Grade Point Average as defined in the Academic Regulations;*

m. *"Clause" means the duly numbered Clause, with Sub-Clauses included, if any, of these Regulations;*

n. *"COE" means the Controller of Examinations of the University;*

o. *"Course In Charge" means the teacher/faculty member responsible for developing and organising the delivery of the Course;*

p. *"Course Instructor" means the teacher/faculty member responsible for teaching and evaluation of a Course;*

q. *"Course" means a specific subject usually identified by its Course-code and Course-title, with specified credits and syllabus/course-description, a set of references, taught by some teacher(s)/course-instructor(s) to a specific class (group of students) during a specific Academic Term;*

r. *"Curriculum Structure" means the Curriculum governing a specific Degree Program offered by the University, and, includes the set of Baskets of Courses along with minimum credit requirements to be earned under each basket for a degree/degree with specialization/minor/honours in addition to the relevant details of the Courses and Course catalogues (which describes the Course content and other important information about the Course). Any specific requirements for a particular program may be brought into the Curriculum structure of the specific program and relevant approvals should be taken from the BOS and Academic Council at that time.*

s. *"DAC" means the Departmental Academic Committee of a concerned Department/Program of Study of the University;*

t. *"Dean" means the Dean / Director of the concerned School;*

u. *"Degree Program" includes all Degree Programs;*

v. *"Department" means the Department offering the degree Program(s) / Course(s) / School offering the concerned Degree Programs / other Administrative Offices;*

w. *"Discipline" means specialization or branch of M.Tech. Degree Program;*

x. *"HOD" means the Head of the concerned Department;*

y. *"L-T-P-C" means Lecture-Tutorial-Practical-Credit – refers to the teaching – learning periods and the credit associated;*

z. *"MOOC" means Massive Open Online Courses;*

aa. *"MOU" means the Memorandum of Understanding;*

ab. *"NPTEL" means National Program on Technology Enhanced Learning;*

ac. *"Parent Department" means the department that offers the Degree Program that a student undergoes;*

ad. *"Program Head" means the administrative head of a particular Degree Program/s;*

ae. *"Program Regulations" means the Master of Technology Degree Program Regulations and Curriculum, 2025-2027;*

af. *"Program" means the Masterr of Technology (M.Tech.) Degree Program;*

ag. "PSCS" means the Presidency School of of Computer Science and Engineering;

ah. "Registrar" means the Registrar of the University;

ai. "School" means a constituent institution of the University established for monitoring, supervising and guiding, teaching, training and research activities in broadly related fields of studies;

aj. "Section" means the duly numbered Section, with Clauses included in that Section, of these Regulations;

ak. "SGPA" means the Semester Grade Point Average as defined in the Academic Regulations;

al. "Statutes" means the Statutes of Presidency University;

am. "Sub-Clause" means the duly numbered Sub-Clause of these Program Regulations;

an. "Summer Term" means an additional Academic Term conducted during the summer break (typically in June-July) for a duration of about eight (08) calendar weeks, with a minimum of thirty (30) University teaching days;

ao. "SWAYAM" means Study Webs of Active Learning for Young Aspiring Minds.

ap. "UGC" means University Grant Commission;

aq. "University" means Presidency University, Bengaluru; and

ar. "Vice Chancellor" means the Vice Chancellor of the University.

5. Program Description

The Master of Technology Degree Program Regulations and Curriculum 2025-2027 are subject to, and, pursuant to the Academic Regulations. These Program Regulations shall be applicable to the following ongoing Master of Technology (M.Tech.) Degree Programs of 2025-2027 offered by the Presidency School of Engineering (PSOE):

1. Master of Technology in Computer Science and Engineering Specialization in Artificial Intelligence.M.Tech. (AIE)
2. Master of Technology in Computer Science and Engineering Specialization in Data Science.M.Tech. (DSC)

5.1 These Program Regulations shall be applicable to other similar programs, which may be introduced in future.

5.2 These Regulations may evolve and get amended or modified or changed through appropriate approvals from the Academic Council, from time to time, and shall be binding on all concerned.

5.3 The effect of periodic amendments or changes in the Program Regulations, on the students admitted in earlier years, shall be dealt with appropriately and carefully, so as to ensure that those students are not subjected to any unfair situation whatsoever, although they are required to conform to these revised Program Regulations, without any undue favour or considerations

6. Minimum and Maximum Duration

6.1 Master of Technology Degree Program is a Two-Year, Full-Time Semester based program. The minimum duration of the M.Tech. Program is four (02) years and each year comprises of two academic Semesters (Odd and Even Semesters) and hence the duration of the M.Tech. program is four (04) Semesters.

6.2 A student who for whatever reason is not able to complete the Program within the normal period or the minimum duration (number of years) prescribed for the Program, may be allowed a period of two years beyond the normal period to complete the mandatory minimum credits requirement as prescribed by the concerned Program Regulations and Curriculum. In general, the permissible maximum duration (number of years) for completion of Program is 'N' + 2 years, where 'N' stands for the normal or minimum duration (number of years) for completion of the concerned Program as prescribed by the concerned Program Regulations and Curriculum.

6.3 The time taken by the student to improve Grades/CGPA, and in case of temporary withdrawal/re-joining (Refer to Clause 16.1 of Academic Regulations), shall be counted in the permissible maximum duration for completion of a Program.

6.4 In exceptional circumstances, such as temporary withdrawal for medical exigencies where there is a prolonged hospitalization and/or treatment, as certified through hospital/medical records, women students requiring extended maternity break (certified by registered medical practitioner), and, outstanding sportspersons representing the University/State/India requiring extended time to participate in National/International sports events, a further extension of one (01) year may be granted on the approval of the Academic Council.

6.5 The enrolment of the student who fails to complete the mandatory requirements for the award of the concerned Degree (refer Section 19.0 of Academic Regulations) in the prescribed maximum duration (Sub-Clauses 18.1 and 18.2 of Academic Regulations), shall stand terminated and no Degree shall be awarded.

7 Programme Educational Objectives (PEO)

After four years of successful completion of the program, the graduates shall be:

PEO 01: To prepare graduates who will be successful professionals in industry, government, academia, research, entrepreneurial pursuit and consulting firms.

PEO 02: To prepare graduates who will contribute to society as broadly educated, expressive, ethical and responsible citizens with proven expertise.

PEO 03: To prepare graduates who will achieve peer recognition as individuals or in a team through demonstration of good analytical, research, design and implementation skills.

PEO 04: To prepare graduates who will thrive to pursue life-long reflective learning to fulfil their goals.

8 Programme Outcomes (PO) and Programme Specific Outcomes (PSO)

8.1 Programme Outcomes (PO)

On successful completion of the Program, the students shall be able to:

PO1:An ability to analysis, manage and supervise engineering systems and processes with the aid of appropriate advanced tools.

PO2:An ability to design a system and process within constraints of health, safety, security, economics, manufacturability to meet desired needs.

PO3:An ability to carry out research in the respective discipline and publish the findings.

PO4:An ability to effectively communicate and transfer the knowledge/ skill to stakeholders.

PO5:An ability to realize the impact of engineering solutions in a contemporary, global, economical, environmental, and societal context for sustainable development.

8.2 Program Specific Outcomes (PSOs):

On successful completion of the Program, the students shall be able to:

PSO 1:

Apply foundational and advanced data science methodologies to analyze, model, and extract meaningful insights from complex and large-scale datasets for solving real-world problems across multiple domains.

PSO 2:

Demonstrate proficiency in designing and deploying scalable, data-driven systems using appropriate tools, technologies, and platforms to support informed decision-making and innovation.

PSO 3:
Exhibit ethical and responsible data handling practices while ensuring data privacy, transparency, and fairness in analytics and machine learning applications for societal and industrial impact.

9 Admission Criteria (as per the concerned Statutory Body)

The University admissions shall be open to all persons irrespective of caste, class, creed, gender or nation. All admissions shall be made on the basis of merit in the qualifying examinations; provided that forty percent of the admissions in all Programs of the University shall be reserved for the students of Karnataka State and admissions shall be made through a Common Entrance Examination conducted by the State Government or its agency and seats shall be allotted as per the merit and reservation policy of the State Government from time to time**.** The admission criteria to the M.Tech. Program is listed in the following Sub-Clauses:

- Have a Bachelor's degree in engineering (B.E./B.Tech) from a recognized university.
- Have a minimum aggregate of 50% in your Bachelor's degree.
- Have a minimum aggregate of 45% in your Bachelor's degree if you belong to a reserved category.
- Have to submit score card from any state or central entrance exam or the Presidency University admission qualifying exam

10. Specific Regulations regarding Assessment and Evaluation (including the Assessment Details of NTCC Courses, Weightages of Continuous Assessment and End Term Examination for various Course Categories)

10.1 The academic performance evaluation of a student in a Course shall be according to the University Letter Grading System based on the class performance distribution in the Course.

10.2 Academic performance evaluation of every registered student in every Course registered by the student is carried out through various components of Assessments spread across the Semester. The nature of components of Continuous Assessments and the weightage given to each component of Continuous Assessments (refer Clause 8.8 of academic regulations) shall be clearly defined in the Course Plan for every Course, and approved by the DAC.

10.3 Format of the End-Term examination shall be specified in the Course Plan.

10.4 Grading is the process of rewarding the students for their overall performance in each Course. The University follows the system of Relative Grading with statistical approach to classify the students based on the relative performance of the students registered in the concerned Course except in the following cases:

- Non-Teaching Credit Courses (NTCC)

Absolute grading method may be adopted, where necessary with prior approval of concerned DAC.

Grading shall be done at the end of the Academic Term by considering the aggregate performance of the student in all components of Assessments prescribed for the Course. Letter Grades shall be awarded to a student based on her/his overall performance relative to the class performance distribution in the concerned Course. These Letter Grades not only indicate a qualitative assessment of the student's performance but also carry a quantitative (numeric) equivalent called the Grade Point.

10.5 Assessment Components and Weightage

Table 1: Assessment Components and Weightage for different category of Courses		
Nature of Course and Structure	**Evaluation Component**	**Weightage**

Lecture-based Course L component in the L-T-P Structure is predominant (more than 1) (Examples: 3-0-0; 3-0-2; 2-1-0; 2-0-2, 2-0-4 etc.)	Continuous Assessments	50%
	End Term Examination	50%
Lab/Practice-based Course P component in the L-T-P Structure is predominant (Examples: 0-0-4; 1-0-4; 1-0-2; etc.)	Continuous Assessments	50%
	End Term Examination	50%
Skill based Courses like Industry Internship, Capstone project, Research Dissertation, Integrative Studio, Interdisciplinary Project, Summer / Short Internship, Social Engagement / Field Projects, Portfolio, and such similar Non-Teaching Credit Courses, where the pedagogy does not lend itself to a typical L-T-P structure	Guidelines for the assessment components for the various types of Courses, with recommended weightages, shall be specified in the concerned Program Regulations and Curriculum / Course Plans, as applicable.	

The exact weightages of Evaluation Components shall be clearly specified in the concerned PRC and respective Course Plan.

Normally, for Practice/Skill based Courses, without a defined credit structure (L–P–C) [NTCC], but with assigned Credits (as defined in Clause 5.2 of the Academic Regulations), the method of evaluation shall be based only on Continuous Assessments. The various components of Continuous Assessments, the distribution of weightage among such components, and the method of evaluation/assessment, shall be as decided and indicated in the Course Plan/PRC. The same shall be approved by the respective DAC.

10.6 Minimum Performance Criteria:

10.6.1 Theory only Course and Lab/Practice Embedded Theory Course

A student shall satisfy the following minimum performance criteria to be eligible to earn the credits towards the concerned Course:

a. A student must obtain a minimum of 30% of the total marks/weightage assigned to the End Term Examinations in the concerned Course.

b. The student must obtain a minimum of 40% of the AGGREGATE of the marks/weightage of the components of Continuous Assessments, Mid Term Examinations and End Term Examinations in the concerned Course.

10.6.2 Lab/Practice only Course and Project Based Courses

The student must obtain a minimum of 40% of the AGGREGATE of the marks/weightage of all assessment components in the concerned Course.

10.6.3 A student who fails to meet the minimum performance criteria listed above in a Course shall be declared as “Fail” and given “F” Grade in the concerned Course. For theory Courses, the student shall have to re-appear in the “Make-Up Examinations” as scheduled by the University in any subsequent semester, or, re-appear in the End Term Examinations of the same Course when it is scheduled at the end of the following Semester or Summer Term, if offered. The marks obtained in the Continuous Assessments (other than the End Term Examination) shall be carried forward and be included in computing the final grade, if the student secures the minimum requirements (as per sub-clause 8.9.1 and 8.9.2 of academic regulations) in the “Make-Up Examinations” of the concerned Course. Further, the student has an option to re-register for the Course and clear the same in the summer term/ subsequent semester if he/she wishes to do so, provided the Course is offered.

11 Additional clarifications - Rules and Guidelines for Transfer of Credits from MOOC, etc. – Note: These are covered in Academic Regulations

The University allows students to acquire credits from other Indian or foreign institutions and/or Massive Open Online Course (MOOC) platforms, subject to prior approval. These credits may be transferred and counted toward fulfilling the minimum credit requirements for the award of a degree. The process of transfer of credits is governed by the following rules and guidelines:

11.1 The transfer of credits shall be examined and recommended by the Equivalence Committee (Refer ANNEXURE B of academic regulations) and approved by the Dean - Academics.

11.2 Students may earn credits from other Indian or foreign Universities/Institutions with which the University has an MOU, and that MOU shall have specific provisions, rules and guidelines for transfer of credits. These transferred credits shall be counted towards the minimum credit requirements for the award of the degree.

11.3 Students may earn credits by registering for Online Courses offered by *Study Web of Active Learning by Young and Aspiring Minds* (SWAYAM) and *National Program on Technology Enhanced Learning* (NPTEL), or other such recognized Bodies/ Universities/Institutions as approved by the concerned BOS and Academic Council from time to time. The concerned School/Parent Department shall publish/include the approved list of Courses and the rules and guidelines governing such transfer of credits of the concerned Program from time to time. The Rules and Guidelines for the transfer of credits specifically from the Online Courses conducted by SWAYAM/ NPTEL/ other approved MOOCs are as stated in the following Sub-Clauses:

11.3.1 A student may complete SWAYAM/NPTEL/other approved MOOCs as mentioned in Clause 11.3 (as per academic regulations) and transfer equivalent credits to partially or fully complete the mandatory credit requirements of Discipline Elective Courses and/or the mandatory credit requirements of Open Elective Courses as prescribed in the concerned Curriculum Structure. However, it is the sole responsibility of the student to complete the mandatory credit requirements of the Discipline Elective Courses and the Open Elective Courses as prescribed by the Curriculum Structure of the concerned Program.

11.3.2 SWAYAM/NPTEL/ other approved MOOCs as mentioned in Clause 11.3 (as per academic regulations) shall be approved by the concerned Board of Studies and placed (as Annexures) in the concerned PRC.

11.3.3 Parent Departments may release a list of SWAYAM/NPTEL/other approved MOOCs for Pre-Registration as per schedule in the Academic Calendar or through University Notification to this effect.

11.3.4 Students may Pre-Register for the SWAYAM/NPTEL/other approved MOOCs in the respective Departments and register for the same Courses as per the schedule announced by respective Online Course Offering body/institute/ university.

11.3.5 A student shall request for transfer of credits only from such approved Courses as mentioned in Sub-Clause 11.3.2 above.

11.3.6 SWAYAM/NPTEL/other approved MOOCs Courses are considered for transfer of credits only if the concerned student has successfully completed the SWAYAM/NPTEL/other approved MOOCs and obtained a certificate of successful/satisfactory completion.

11.3.7 A student who has successfully completed the approved SWAYAM/NPTEL/ other approved MOOCs and wants to avail the provision of transfer of equivalent credits, must submit the original Certificate of Completion, or such similar authorized documents to the HOD concerned, with a written request for the transfer of the equivalent credits. On verification of the Certificates/Documents and approval by the HOD concerned, the Course(s) and equivalent Credits shall forwarded to the COE for processing of results of the concerned Academic Term.

11.3.8 The credit equivalence of the SWAYAM/NPTEL/other approved MOOCs are based on Course durations and/or as recommended by the Course offering body/institute/university. The Credit Equivalence mapped to SWAYAM/ NPTEL approved Courses based on Course durations for transfer of credits is summarised in Table shown below. The Grade will be calculated from the marks received by the Absolute Grading Table 8.11 in the academic regulations.

Table 2: Durations and Credit Equivalence for Transfer of Credits from SWAYAM-NPTEL/ other approved MOOC Courses

Sl. No.	Course Duration	Credit Equivalence
1	4 Weeks	1 Credit
2	8 Weeks	2 Credits
3	12 Weeks	3 Credits

11.3.9 The maximum permissible number of credits that a student may request for credit transfer from MOOCs shall not exceed 20% of the mandatory minimum credit requirements specified by the concerned Program Regulations and Curriculum for the award of the concerned Degree.

11.3.10 The University shall not reimburse any fees/expense; a student may incur for the SWAYAM/NPTEL/other approved MOOCs.

11.4 The maximum number of credits that can be transferred by a student shall be limited to forty percent (40%) of the mandatory minimum credit requirements specified by the concerned Program Regulations and Curriculum for the award of the concerned Degree. However, the grades obtained in the Courses transferred from other Institutions/MOOCs, as mentioned in this Section (11.0), shall not be included in the calculation of the CGPA.

PART B: PROGRAM STRUCTURE

12. 0 Structure / Component with Credit Requirements Course Baskets & Minimum Basket wise Credit Requirements

The M.Tech. CSE Specialization in (Data Science) Program Structure (2025-2027) totalling 68credits. Table 3 summarizes the type of baskets, number of courses under each basket and the associated credits that are mandatorily required for the completion of the Degree.

Table 3: Summary of mandatory courses and minimum credit contribution from various baskets		
S.No	**Baskets**	**Credit Contribution**
1	SCHOOL CORE	32
2	PROGRAM CORE	15
3	DISCIPLINE ELECTIVE	15
4	OPEN ELECTIVE	06
	TOTAL CREDITS	**Min. 68**

In the entire Program, the practical and skill based course component contribute to an extent of approximately 61% out of the total credits of 68 for M.Tech. (Product Design and Development) program of twoyears' duration.

13. Minimum Total Credit Requirements of Award of Degree

As per the AICTE guidelines, a minimum of 68 credits is required for the award of a M.Tech. degree.

14. Other Specific Requirements for Award of Degree, if any, as prescribed by the Statutory Bodies,

14.1 The award of the Degree shall be recommended by the Board of Examinations and approved by the Academic Council and Board of Management of the University.

14.2 A student shall be declared to be eligible for the award of the concerned Degree if she/he:

a. Fulfilled the Minimum Credit Requirements and the Minimum Credits requirements under various baskets;

b. Secure a minimum CGPA of 5.0 in the concerned Program at the end of the Semester/Academic Term in which she/he completes all the requirements for the award of the Degree as specified in Sub-clause 19.2.1 a of Academic Regulations;

c. No dues to the University, Departments, Hostels, Library, and any other such Centers/ Departments of the University; and

d. No disciplinary action is pending against her/him.

PART C: CURRICULUM STRUCTURE

15. Curriculum Structure – Basket Wise Course List (not Semester Wise)
List of Courses Tabled – aligned to the Program Structure
(Course Code, Course Name, Credit Structure (LTPC), Contact Hours, Course Basket, Type of Skills etc., as applicable).

Type of Skill
F - Foundation **S - Skill Development** **EM - Employability** **EN – Entrepreneurship**

Course Caters to
GS - Gender Sensitization **ES - Environment and sustainability** **HP - Human values and Professional Ethics**

Table 3.1 : List of School Core (SC)

S.No	Course Code	Course Name	L	T	P	C	Contact Hours	Type of Skills	Pre requisite
1	MAT6001	Advanced Engineering Mathematics	3	0	0	3	3	S	-
2	ENG5001	English for Employability	2	1	0	3	3	S	-
3	SEM5001	Seminar – I	-	-	-	1		S/EM	-
4	SEM5002	Seminar – II	-	-	-	1		S/EM	-
5	PIP6001	Dissertation/ Internship – I	-	-	-	10		S/EM	-
6	PIP6002	Dissertation/ Internship – II	-	-	-	14		S/EM	-
		Total No. of Credits				**32**			

Table 3.2 : List of Programme Core Courses (PC)

S.No	Course Code	Course Name	L	T	P	C	Contact Hours	Type of Skills	Pre requisite
1	DSC4000	Statistics for Data Science	3	0	0	3	3	S	-
2	DSC4001	Programming in Data Science	2	0	2	3	4	S	-
3	DSC4002	Data Analytics and Visualization	2	0	2	3	4	S	-
4	DSC4003	Data Mining and Predictive Analytics	2	0	2	3	4	S	-
5	DSC4004	Big Data Analytics Tools and Techniques	2	0	2	3	4	S	-
		Total No. of Credits				**15**			

16. Practical / Skill based Courses – Internships / Thesis / Dissertation / Capstone Project Work / Portfolio / Mini project

Practical / Skill based Courses like internship, project work, capstone project, research project / dissertation, and such similar courses, where the pedagogy does not lend itself to a typical L-T-P-C Structure as defined in Clause 5.1 of the Academic Regulations are simply assigned the number of Credits based on the quantum of work / effort required to fulfill the learning objectives and outcomes prescribed for the concerned Courses. Such courses are referred to as Non-Teaching Credit Courses (NTCC). These Courses are designed to provide students with hands-on experience and skills essential for their professional development. These courses aim to equip students with abilities in problem identification, root cause analysis, problem-solving, innovation, and design thinking through industry exposure and project-based learning. The expected outcomes are first level proficiency in problem solving and design thinking skills to better equip M.Tech. graduates for their professional careers. The method of evaluation and grading for the Practical / Skill based Courses shall be prescribed and approved by the concerned Departmental Academic Committee (refer Annexure A of the Academic Regulations). The same shall be prescribed in the Course Handout.

16.1 Internship

A student may undergo an Internship for a period of 12-14 weeks in an industry / company or academic / research institution during 3rd and 4th Semesters, subject to the following conditions:

16.1.1 The Internship shall be in conducted in accordance with the Internship Policy prescribed by the University from time to time.

16.1.2 The selection criteria (minimum CGPA, pass in all Courses as on date, and any other qualifying criteria) as applicable / stipulated by the concerned Industry / Company or academic / research institution for award of the Internship to a student;

16.1.3 The number of Internships available for the concerned Academic Term. Further, the available number of internships shall be awarded to the students by the University on the basis of merit using the CGPA secured by the student. Provided further, the student fulfils the criteria, as applicable, specified by the Industry / Company or academic / research institution providing the Internship, as stated in Sub-Clause 16.1.2 above.

16.1.4 A student may opt for Internship in an Industry / Company or academic / research institution of her / his choice, subject to the condition that the concerned student takes the responsibility to arrange the Internship on her / his own. Provided further, that the Industry / Company or academic / research institution offering such Internship confirms to the University that the Internship shall be conducted in accordance with the Program Regulations and Internship Policy of the University.

16.1.5 A student selected for an Internship in an industry / company or academic / research institution shall adhere to all the rules and guidelines prescribed in the Internship Policy of the University.

16.2 Project Work

A student may opt to do a Project Work for a period of 12-15 weeks in an Industry / Company or academic / research institution or the University Department(s) as an equivalence of Internship during the 3rd and 4th Semester as applicable, subject to the following conditions:

16.2.1 The Project Work shall be approved by the concerned HOD and be carried out under the guidance of a faculty member.

16.2.2 The student may do the project work in an Industry / Company or academic / research institution of her / his choice subject to the above mentioned condition (Sub-Clause 16.2.1). Provided further, that the Industry / Company or academic / research institution offering such project work confirms to the University that the project work will be conducted in accordance with the Program Regulations and requirements of the University.

16.3 Capstone Project

A student may undergo a Capstone Project for a period of 12-14 weeks in an industry / company or academic / research institution in the 4th Semester as applicable, subject to the following conditions:

16.3.1 The Capstone Project shall be in conducted in accordance with the Capstone Project Policy prescribed by the University from time to time.

16.3.2 The selection criteria (minimum CGPA, pass in all Courses as on date, and any other qualifying criteria) as applicable / stipulated by the concerned Industry / Company or academic / research institution for award of the Capstone Project to a student;

16.3.3 The number of Capstone Project available for the concerned Academic Term. Further, the available number of Capstone Project shall be awarded to the students by the University on the basis of merit using the CGPA secured by the student. Provided further, the student fulfils the criteria, as applicable, specified by the Industry / Company or academic / research institution providing the Capstone Project, as stated in Sub-Clause 16.3.2 above.

16.3.4 A student may opt for Capstone Project in an Industry / Company or academic / research institution of her / his choice, subject to the condition that the concerned student takes the responsibility to arrange the I Capstone Project on her / his own. Provided further, that the Industry / Company or academic / research institution offering such Capstone Project confirms to the University that the Capstone Project shall be conducted in accordance with the Program Regulations and Capstone project Policy of the University.

16.3.5 A student selected for a Capstone Project in an industry / company or academic / research institution shall adhere to all the rules and guidelines prescribed in the Capstone Project Policy of the University.

16.4 Research Project / Dissertation

A student may opt to do a Research Project / Dissertation for a period of 12-14 weeks in an Industry / Company or academic / research institution or the University Department(s) as an equivalence of Capstone Project, subject to the following conditions:

16.4.1 The Research Project / Dissertation shall be approved by the concerned HOD and be carried out under the guidance of a faculty member.

The student may do the Research Project / Dissertation in an Industry / Company or academic / research institution of her / his choice subject to the above mentioned condition (Sub-Clause 18.4.1). Provided further, that the Industry / Company or academic / research institution offering such Research Project / Dissertation confirms to the University that the Research Project / Dissertation work will be conducted in accordance with the Program Regulations and requirements of the University.

17. **List of Discipline Elective Courses:**

Table 3.3 DISCIPLINE ELECTIVE - Minimum of 15 Credits to be earned from this basket									
Sl. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**	**Contact Hours**	**Type of Skill/ Focus**	**Prerequisites/ Corequisites**
1	DSC4011	Data Science with Cloud Computing	3	0	0	3	3	S	-
2	DSC4012	Data Security and Access Control	3	0	0	3	3	S	-
3	DSC4013	Soft Computing Techniques	3	0	0	3	3	S	-
4	DSC4014	Time Series Analysis and Forecasting	3	0	0	3	3	S	-
5	DSC4015	IOT Data Analytics	3	0	0	3	3	S	-
6	DSC4016	Probabilistic Graph Models	3	0	0	3	3	S	-
7	DSC4017	Social Network Analysis	3	0	0	3	3	S	-
8	DSC4018	Application of Probability theory in Computer Science	3	0	0	3	3	S	-
9	DSC4019	Digital Image Processing	2	0	2	3	4	S	-
10	DSC4020	Data Mining and Pattern Recognition	2	0	2	3	4	S	-
11	DSC4021	Graph Analytics and Network Science	2	0	2	3	4	S	-
12	DSC4022	Geospatial Data Science	2	0	2	3	4	S	-
13	DSC4023	Marketing and Consumer Analytics	3	0	0	3	3	S	-
14	DSC4024	Multimodal Learning	2	0	2	3	4	S	-
15	DSC4025	Intelligent Decision Support Systems	2	0	2	3	4	S	-
16	AIE4011	Robotic Process Automation	3	0	0	3	3	S	-
17	AIE4012	Machine Vision	3	0	0	3	3	S	-
18	AIE4013	Cloud Computing	3	0	0	3	3	S	-
19	AIE4014	Ontology Engineering for the Semantic Web	3	0	0	3	3	S	-

20	AIE4015	Intelligent Information Retrieval	3	0	0	3	3	S	-
21	AIE4016	Internet of Things	3	0	0	3	3	S	-
22	AIE4017	Essentials for Machine Learning	3	0	0	3	3	S	-
23	AIE4018	Recommender Systems with Machine Learning and AI	3	0	0	3	3	S	-
24	AIE4019	Green Computing and Sustainable IT	3	0	0	3	3	S	-
25	AIE4020	Reinforcement Learning	2	0	2	3	4	S	-
26	AIE4021	AI Ethics and Responsible AI	2	0	2	3	4	S	-
27	AIE4022	Generative AI and Foundation Models	2	0	2	3	4	S	-
28	AIE4023	Explainable AI	2	0	2	3	4	S	-
29	AIE4024	Digital Twins	2	0	2	3	4	S	-
30	AIE4025	Quantum Computing	2	0	2	3	4	S	-

18. List of Open Electives to be offered by the School / Department (Separately for ODD and EVEN Semesters.

Table 3.4 Open Elective Courses Minimum of 6 Credits to be earned from this basket									
Civil Engineering Basket									
Sl. No.	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**	**Contact Hours**	Type of Skills	**Prerequisites**
1	CIV5001	Sustainable Smart Cities	3	0	0	3	3	EM	-
2	CIV5002	Systems Design for Sustainability	3	0	0	3	3	EM	-
3	CIV5003	SelfSustainable Buildings	3	0	0	3	3	EM	-
4	CIV5004	Energy and Buildings	3	0	0	3	3	EM	-
Law Basket									
1	LAW5001	International Trade Law	3	0	0	3	3	-	-
2	LAW5002	Law relating to Business Establishment	3	0	0	3	3		

								-	-
3	LAW5003	Data Protection Law	3	0	0	3	3	-	-
4	LAW5004	Law Relating to Consumer Protection	3	0	0	3	3	-	-
5	LAW5005	Law Relating to Infrastructure Projects	3	0	0	3	3	-	-
Computer Science and Engineering Basket									
1	CSE5001	Programming Methodologies using Java	3	0	0	3	3	-	-
2	CSE5002	Human Computer Interaction	3	0	0	3	3	-	-
3	CSE5003	IOT Applications	3	0	0	3	3	-	-
4	CSE5004	Programming Essentials in Python	3	0	0	3	3	-	-
Electronics and Communication Engineering Basket									
1	ECE5001	Wearable Computing	3	0	0	3	3	-	-
2	ECE5002	MEMS and Nanotechnology	3	0	0	3	3	-	-
3	ECE5003	Advanced Computer Networks	3	0	0	3	3	-	-
4	ECE5004	Pervasive Computing	3	0	0	3	3	-	-
Mechanical Engineering Basket									
1	MEC5001	Optimization Techniques	3	0	0	3	3	-	-
2	MEC5002	Industry 4.0	3	0	0	3	3	EM	-
3	MEC5003	Six Sigma for Engineers	3	0	0	3	3	-	-
4	MEC5004	Design for Internet of Things	3	0	0	3	3	-	-
Management Basket									
1	MBA3042	Innovation and Business	3	0	0	3	3		

		Incubation						-	-
2	MBA3037	Personal Wealth Management	3	0	0	3	3	-	-
3	MBA3038	Team Dynamics	3	0	0	3	3	-	-
4	MBA3039	Market Research	3	0	0	3	3	-	-
5	MBA2023	Design Thinking for Business Innovation	3	0	0	3	3	-	-
6	MBA3046	Game Theory in Business	3	0	0	3	3	-	-
7	MBA3047	Data Story Telling	3	0	0	3	3	-	-
8	MBA3048	Environmental Sustainability and Value Creation	3	0	0	3	3	-	-
9	MBA3049	Industry 4.0	3	0	0	3	3	-	-
Media Studies Basket									
1	BAJ5001	Media and Entertainment Business	3	0	0	3	3	EN	-
2	BAJ5002	TV Journalism and News Management	2	0	2	3	4	EM	-
Research Basket									
1	RES5001	Research Methodology	3	0	0	3	3	S	-
2	RES3001	Research Methodology	3	0	0	3	3	S	-
Research Project (Students are required to carry out research work under the guidance of a faculty member/ research scholar and the same shall be evaluated and credit will be granted as per the academic regulations)									
1	URE7001	University Research Experience	-	-	-	3		EM	-
2	URE7002	University Research Experience	-	-	-	0		EM	-
Apart from the above list, the student is free to enroll for any course offered by any school and earn credits for Open elective provided the student has not completed an antirequisite course and the student fulfills the prerequisite if any for the course he wishes to enroll									

Recommended Semester Wise Course Structure / Flow including the Programme / Discipline Elective Paths / Options

Sl. No.	Course Code	Course Name	L	T	P	Credits	Contact Hours	Basket
Semester 1						**22**	**25**	
1	MAT4004	Advanced Engineering Mathematics	4	0	0	4	4	School Core
2	ENG5001	English for Employability	2	1	0	3	3	School Core
3	DSC4000	Statistics for Data Science	3	0	0	3	3	Program Core
4	DSC4001	Programming in Data Science	2	0	2	3	4	Program Core
6	DSC4002	Data Analytics and Visualization	2	0	2	3	4	Program Core
8	XXXXXX	Discipline Elective - I	2	0	2	3	4	Discipline Elective
9	XXXXXX	Discipline Elective - II	2	0	2	3	4	Discipline Elective
Semester 2						**22**	**24**	
1	DSC4003	Data Mining and Predictive Analytics	2	0	2	3	4	Program Core
2	DSC4004	Big Data Analytics Tools and Techniques	2	0	2	3	4	Program Core
3	xxxxxx	Discipline Elective - III	2	0	2	3	4	Discipline Elective
4	xxxxxx	Discipline Elective - IV	3	0	0	3	3	Discipline Elective
5	xxxxxx	Discipline Elective - V	3	0	0	3	3	Discipline Elective
6	xxxxxx	Open Elective - I	3	0	0	3	3	Open Elective
7	xxxxxx	Open Elective - II	3	0	0	3	3	Open Elective
8	SEM7000	Seminar	-	-	-	1	0	School Core
Semester 3						**10**	**0**	
1	PIP7500	Dissertation/ Internship - I	-	-	-	10		School Core
Semester 4						**14**	**0**	
1	PIP7501	Dissertation/ Internship - II	-	-	-	14		School Core
						68		

I. Course Catalogues:

Each course shall have a course catalogue with the following details:

i) Pre –Requisites of the course
ii) Course Description
iii) Course Outcome
iv) Course Content
iv) Reference Resources.

The Course Catalogues for the Courses offered in each basket are attached below:

Course Code: DSC4001	**Course Title: Programming in Data Science** **Type of Course:** **Program Core** **Theory and Laboratory Integrated**		**L-T-P-C**	2	0	2	3
Version No.		2.0				
Course Pre-requisites		--				
Anti-requisites		Python, R Programming Language				
Course Description		This course introduces the core concepts of Data Science followed by programming using Python and R. This course has theory and lab component which emphasizes on understanding and programming right from Basics to Visualization in Python and R. It helps the student to explore data by applying these concepts and also for effective problem solving, visualizing and analyzing.				
Course Objective		The objective of the course is to familiarize the learners with the concepts of Programming in Data Science and attain SKILL DEVELOPMENT through EXPERIENTIAL LEARNING techniques				
Course Out Comes		On successful completion of the course the students shall be able to: CO1: Discuss about the process involved in Data Science CO2: Explore Data using Python Numpy and Pandas CO3: Demonstrate Data Visualization using Matplotlib CO4: Explore Data using R and Visualize using R Graphics				
Course Content:						

Module 1	Introduction to Data Science	Assignment	Case Studies		**10 Sessions**
	Topics: **Introduction to Data Science** –- The field of Data Science – The various Data Science Disciplines, Connecting the Data Science Disciplines, Features of R, Data Science Techniques and Tools – Types of Data – Measures and Metrics – Descriptive Statistics – Inferential Statistics. **Data Science Methodology** - From Problem to Approach and From Requirements to Collection, From Understanding to Preparation and From Modeling to Evaluation, From Deployment to Feedback. **Data Preprocessing** - Data Quality Assessment, Feature Aggregation, Dimensionality Reduction, Feature Encoding. Predictive and descriptive analytics.				
Module 2	Data Exploration using Numpy and Pandas	Assignment	Programming		**8 Sessions**
	Topics: Introduction to Python World, Motivation, Installation of **NUMPY**, Numpy Basics, Placeholders,				

	Datatypes, Arrays, Basic Statistics, Copying, Slicing & Subsetting, Indexing, Flattening, Reshaping, Resizing, Sorting, Swapping, Dealing with Missing values. **PANDAS** - the PYTHON Data Analysis Library, Motivation, Installation of PANDAS, PANDAS Data Structure, Series, Dataframe, Loading the Data, Descriptive Statistics, Indexing & ReIndexing, Renaming, Iteration, Sorting, Statistical functions, for and while loop in R, Window functions, Aggregations. Number of Missing values in single variable. Groupby Operations, Merging/Joining, Concatenation, Time Series, Working with Categorical Data and Text Data.					
Module 3	I/O Tools and Visualization	Assignment	Mini Project		**8 Sessions**	
	Topics: **I/O API Tools**, CSV and Textual files, Reading data in CSV or text files, Using RegExp to parse txt files, Reading txt files into parts, Writing data in CSV, Reading and Writing HTML files, Reading data from XML, Reading and Writing data from excel file, JSON Data, Data inspection The **Matplotlib library**, Installation, A simple interactive chart, Adding elements to the chart, Adding a grid, Adding a legend, Converting the session to an html file, Saving your chart directly as an image, Handling date values, Chart typology, Line charts, Histograms, Bar charts, Horizontal Bar Charts, Multiseries bar charts, Pie chart. Preparing time series data.					
Module 4	Introduction to R	Assignment	Programming		**10 Sessions**	
	Topics: **R Environment**, Using R Studio, Vectors, List, Matrices, Arrays, Data Frames, Factors. Functions - Conditional Functions, User Defined Functions. Reading Data from files, Handling Missing Data, Installing Packages, **R Graphics** – Plot, Line, Scatter Plot, Pie Charts, Bars, Histogram, Box Plots, 3D Pie Charts, 3D Scatter Plot, Visualization with GG Plot. **R Statistics** – Dataset, Max & Min, Mean Median Mode, Subgroup Analyses, Probability Distributions, Pipes in R.					
	List of Laboratory Tasks: **Experiment No 1:** Create a Numpy array and perform the following operations on it **Level 1:** Basic Statistics, Copying, Slicing & Subsetting, Indexing, Flattening, Reshaping, Resizing, **Level 2:** Sorting, Swapping, Dealing with Missing values **Experiment No. 2:** Create a PANDAS Data frame and perform the following operations on it **Level 1:** Descriptive Statistics, Indexing & ReIndexing, Renaming, Iteration, Sorting, Dealing with Missing Data **Level 2:** Statistical functions, Window functions, Aggregations **Experiment No. 3:** Create a PANDAS Data frame and perform the following operations on it **Level 1:** Group by Operations, Merging/Joining, Concatenation, **Level 2:** Time Series, Categorical Data and Text Data **Experiment No. 4:** Demonstrate Reading and Writing using IO API tools **Level 1**: CSV and EXCEL files, HTML and XML files, **Level 2:** HDF5 CPickle **Experiment No. 5:** Using Matplotlib, Visualize the Data **Level 1**: Visualize the data using Line Chart, Bar Charts, Pie Chart, Histograms, Bar chart, Horizontal Bar Chart **Level 2:** Visualize the data using Multiseries Bar Chart, Multiseries Stacked Bar Chart **Experiment No. 6:** Install R Studio and perform basic operations **Level 1:** Vectors, List, Matrices, Arrays, Data Frames, Factors, **Level 2:** Functions and handling Missing Data					

	Experiment No. 7: Using R graphics perform the following **Level 1:** Plot, Line, Scatter Plot, Pie Charts, Bars, Histogram, Box Plots, **Level 2:** 3D Pie Charts, 3D Scatter Plot, GG Plot **Experiment No. 8:** Using R Statistics perform the following **Level 1:** Max & Min, Mean Median Mode, Subgroup Analyses, **Level 2:** Probability Distributions and Pipes
	Targeted Application & Tools that can be used: • Data Exploration • Data Visualization • Data Analysis **Tools**: • Google Colab • Anaconda • R Studio
	Project work
•	• A scenario will be given to the students to be developed as a series of Program/ Application. • On completion of Module 2 and Module 4, students will be asked to develop a Mini Project using Python and R.
	Text Book T1. The essentials of Data Science, Knowledge Discovery Using R, Graham J Williams, CRC Press, 2017 T2. PYTHON Data Analysis, APRESS Publications, Fabio Nelli, 2015
	References R1. Comparative Approaches to using R and PYTHON for Statistical Data Analysis, Information Series Reference, 2018 R2. Practical Data Science CookBook, APRESS Publications, 2018 **Weblinks** W1.https://presiuniv.knimbus.com/user#/home W2.https://www.simplilearn.com/data-science-free-course-for-beginners-skillup
	Topics relevant to "SKILL DEVELOPMENT": Data Exploration, Data Analysis and Visualization using Python and R Programming. for Skill Development through Experiential Learning techniques. This is attained through assessment component mentioned in course handout.

Course Code: DSC4002	**Course Title: Data Analytics and Visualization** **Type of Course: Program Core** **Theory and Laboratory Integrated Course**		**L-T-P-C**	2	0	2	3
Version No.		2.0					
Course Pre-requisites		--					
Anti-requisites		NIL					
Course Description		The Course consists of two parts where first Part covers advanced analytics that covers topics necessary to give businesses greater insight into their data than they could ordinarily, and the Second Part covers data visualization concepts. Primary concepts include machine learning, data mining, predictive analytics, location analytics, big data analytics, and location intelligence. Visualization for Time series, Geolocated data, Correlations, connections, Hierarchies, networks, and interactivity.					

Course Objective	The objective of the course is to familiarize the learners with the concepts of **Data Analytics and Visualization** and attain EMPLOYABILITY SKILLS through PARTICIPATIVE LEARNING techniques				
Course Out Comes	On successful completion of the course the students shall be able to: CO1: Analyze data by performing Exploratory Data Analysis. CO2: Apply techniques of Machine Learning to build Generalized Predictive Models. CO3: Explain basic concepts of Data Visualization. CO4: Apply principles of Data Visualizations to provide insights from data.				
Course Content:					
Module 1	Data Analytics	Assignment	Analysis, Data Collection		**11 Sessions**
	Topics: Characteristics and types of data, Types of Analytics, Location Analytics, Working with Geospatial Data, Feature Engineering and Selection, Dimensionality Reduction Techniques, Common challenges faced during analysis				
Module 2	Advanced Analytics	Case Study	Analysis, Data Collection, Programming		**13 Sessions**
	Topics: Statistical methods for Data Analytics, Advance topics in Supervised and Unsupervised Machine Learning: Cluster Analysis, Hyper-Parameter Tuning, Measuring Performance of the Models, Model Selection, Data Mining techniques.				
Module 3	Introduction to Data Visualization	Assignment	Analysis, Data Collection		**9 Sessions**
	Topics: Importance of analysis and visualization in the era of data abundance, Fundamentals of Data Visualization, Human Perception, Basic plotting techniques, Interaction concepts, Visualization techniques for Time Oriented data, Introduction to Data Visualization Tools				
Module 4	Application - Data Visualization	Case Study	Analysis, Data Collection, Programming		**14 Sessions**
	Topics: Designing effective Visualizations, Advanced Visualization Tools, Visualizing Geospatial Data, Document Visualization, Visualization Systems, Evaluating Visualizations, Visualization Benchmarking. Use cases of data visualization.				
	List of Laboratory Tasks: **Experiment No 1: Exploratory Data analysis** **Level 1:** Demonstration of Tools to implement EDA **Level 2:** Use the Dataset to analyze and summarize data, analyze anomalies, analyze Outliers, and Missing Value Treatment **Experiment No. 2: Dimensionality Reduction Techniques** **Level 1:** Implement DR Technique(s) **Experiment No. 3: Machine Learning Methods** **Level 1:** Implement Supervised Learning Techniques for the given dataset				

	Level 2: Implement Un-Supervised Learning Techniques for the given dataset and Cluster Analysis **Experiment No. 4: Measure the Performance of the Models** **Level 1**: Perform Model Selection **Level 2**: Regularize the model **Experiment No. 5: Introduction to Data Visualization Tools** **Level 1**: Implement Basic plotting techniques **Experiment No. 6: Time Oriented data** **Level 1:** Visualization techniques for Time Oriented data **Experiment No. 7: Trees, Graphs, Networks** **Level 1:** Visualization techniques for Trees, Graphs, Networks **Experiment No. 8: Advanced Visualization Tools** **Level 1:** Design effective Visualizations for the given scenario **Level 2**: Implement Visualizing of Geospatial Data and Document Visualization **Experiment No. 9: Analyze Visualization Systems** **Level 1:** Analyze Visualization Systems
	Targeted Application & Tools that can be used: Data visualization is the graphical representation of information and data. By using visual elements like charts, graphs, and maps, data visualization tools provide an accessible way to see and understand trends, outliers, and patterns in data. In the world of Big Data, data visualization tools and technologies are essential to analyze massive amounts of information and make data-driven decisions. **Tools**: 1. R Programming 2. Python 3. Tableau 4. SAS 5. Excel 6. RapidMiner 7. IBM Cognos Analytics 8. Microsoft Power BI
	Project work:
	After completion of each module a Data analysis or programming based Assignment/Assessment will be conducted. **Mini Project:** Perform exploratory data analysis on a given dataset and provide insights on the same. **1. Crunchbase** – Find business information about private and public companies. You can look up how many investments they had, who the founding members are, and if they had any mergers or acquisitions. **2. Glassdoor Research** – Glassdoor offers data related to employment. You can, for example,

	figure out how much you can save by retaining employees. **3. Open Corporates** – Open Corporates is the largest open database of companies and company data in the world. Used by banks and governments, they pride themselves on having the most accurate data. 4. **FBI Uniform Crime Reporting –** The Uniform Crime Reporting compiles statistical crime reports, publications, and data points from thousands of cities, universities, states, and federal law enforcement agencies. 5. **Uppsala Conflict Data Program** – The Uppsala Conflict Data Program (UCDP) provides data on organized crime and civil war around the world. 6. **National Institute on Drug Abuse** – The National Institute on Drug Abuse (NIDA) monitors the prevalence and trends regarding drug abuse in the United States. 7. **DBpedia** – DBpedia aims to make Wikipedia's information easily searchable via SPARQL queries or by downloading their information directly. For instance, you can search for NBA players born in the 80s, in cities with more than 1M inhabitants. 8. **Google Trends** – Google Trends allows you to look at what's going on in the world. It gives you data about what's becoming popular, and how much people are searching for a particular term. 9. **Instagram API** – Facebook allows you to use Instagram's API to quickly access comments, metadata, and metrics. 10. **Comtrade** – Official trade in goods and services data sets managed by the UN COMTRADE database. There are data visualization tools and an API and other extraction tools available. 11. **Datahub – Stock Market** – From gold prices, NASDAQ listings, to S&P 500 companies, you'll find it all on datahub.io 12. **Global Financial Data** – Global Financial Data gives you exactly what it says on the tin; data about the finances of the world. Ranges from real estate, global macro data, to market data. 13. **IMF Data** – The IMF, or International Monetary Fund, is an organization that aims to foster monetary collaboration between countries. You can find data on trade, government finance, and financial development. 14. **The Atlas of Economic Complexity** – The Atlas of Economic Complexity provides data about global trade dynamics over time. Want to know the quantity of textiles China exported to South Korea? Easy. 15. **World Bank** – Not only does the World Bank provide financial data about countries, but it also provides data on education and health. 16. **Financial Times Data** – Here you'll find cold, hard numbers about the different markets in the world. Data include fluctuations in currency, yield rates of bonds, and commodity prices.
	Text Book T1. Wilke, Claus O. Fundamentals of data visualization: a primer on making informative and compelling figures. O'Reilly Media, 2019. T2. Ward, Grinsten, Keim. Interactive Data Visualization: Foundations, Techniques, and Applications, A K Peters/CRC Press,2nd Edition, 2015
	References **R1.** Mohammed J. Zaki, and Wagner Meira Jr., "Data Mining and Analysis: Fundamental Concepts and Algorithms", Cambridge University Press, 2016 R2. I.H. Witten and E. Frank, Data Mining: Practical Machine learning tools and techniques Morgan Kaufmann publishers; 3rd Edition, 2011 **Weblinks** W1.https://presiuniv.knimbus.com/user#/home W2. https://www.geeksforgeeks.org/short-note-on-data-visualization/
	Topics relevant to "EMPLOYABILITY SKILLS": Real time decision-making application development using Data visualization tools for EMPLOYABILITY SKILLS through Participative Learning techniques. This is attained through assessment component mentioned in course handout.

Course Code: DSC4000
Course Title: Statistics for Data Science
Type of Course: Program Core
L-T-P-C: 3-0-0-3
Total Hours: 45 Hours
Version No.: 1.0
Course Prerequisites:--

Course Description:
This course provides fundamental knowledge of statistics that underpins data science methodologies. It includes descriptive and inferential statistical methods, probability theory, hypothesis testing, regression, and multivariate analysis. The course focuses on data interpretation and statistical reasoning necessary for real-world data-driven decision-making.

Course Objectives:

- **Understand the foundational concepts of descriptive and inferential statistics.**
- **Apply probability theory to model and analyze data uncertainty.**
- **Conduct hypothesis testing and regression analysis.**
- **Interpret statistical findings in the context of data science problems.**

Course Outcomes (COs):

- **CO1 (Understand): Understand and describe the fundamentals of descriptive statistics and data distributions.**
- **CO2 (Analyze): Analyze data using statistical techniques including probability and inferential methods.**
- **CO3 (Apply): Apply hypothesis testing and regression models for problem-solving.**
- **CO4 (Apply): Use multivariate statistical tools to model and interpret complex data sets.**

Course Content (Total: 45 Hours)
Module 1: Descriptive Statistics and Data Visualization (CO1 – Understand) – 10 Hours
Topics: Data types and measurement scales, central tendency (mean, median, mode), dispersion (variance, standard deviation, IQR), data visualization (histograms, boxplots, scatterplots), correlation and covariance.
Module 2: Probability and Distributions (CO2 – Analyze) – 12 Hours
Topics: Basic probability rules, conditional probability, Bayes' theorem, random variables, probability distributions (Bernoulli, Binomial, Poisson, Normal), expectation and variance.
Module 3: Statistical Inference and Hypothesis Testing (CO3 – Apply) – 12 Hours
Topics: Sampling distributions, central limit theorem, confidence intervals, hypothesis testing (Z-test, t-test, Chi-square test, ANOVA), p-values, Type I and II errors.
Module 4: Regression and Multivariate Analysis (CO4 – Apply) – 11 Hours
Topics: Simple and multiple linear regression, assumptions, R-squared, residual analysis, logistic regression, multicollinearity, PCA (Principal Component Analysis), clustering basics.

Textbooks:

- **T1: Allen B. Downey, *Think Stats: Probability and Statistics for Programmers*, 2nd Edition, O'Reilly Media, 2014.**
- **T2: Larry Wasserman, *All of Statistics: A Concise Course in Statistical Inference*,**

Springer, 2010.

Reference Books:

- **R1: William Mendenhall, Robert J. Beaver, and Barbara M. Beaver, *Introduction to Probability and Statistics*, Cengage Learning.**
- **R2: Sheldon M. Ross, *Introduction to Probability and Statistics for Engineers and Scientists*, Academic Press.**

Web Resources:

- **[W1] https://www.khanacademy.org/math/statistics-probability**
- **[W2] https://stattrek.com/**
- **[W3] https://www.coursera.org/learn/statistics**

Course Code: DSC4003
Course Title: Data Mining and Predictive Analytics
Type of Course: Program Core (Integrated Theory and Laboratory)
L-T-P-C: 2-0-2-3
Total Hours: 30 Hours Theory + 30 Hours Lab = 60 Hours
Version No.: 1.0
Course Prerequisites: Basic Statistics and Programming
Anti-requisites: —

Course Description:
This course introduces fundamental concepts, techniques, and algorithms used in data mining and predictive analytics. Emphasis is placed on extracting meaningful patterns from data and applying predictive models for classification, regression, clustering, and association rule mining. The course integrates hands-on experience through labs and tools.

Course Objectives:

- Understand the foundations and applications of data mining.
- Explore different data preprocessing and transformation techniques.
- Apply classification, clustering, and association rule mining algorithms.
- Evaluate and interpret predictive models using appropriate metrics.

Course Outcomes (COs):

- **CO1 (Analyze):** Analyze data mining techniques and data preparation methods.
- **CO2 (Analyze):** Examine predictive modeling approaches for classification and regression tasks.
- **CO3 (Apply):** Apply clustering and association rule mining algorithms on datasets.
- **CO4 (Apply):** Implement data mining solutions using real-world datasets and tools.

Course Content (Total: 60 Hours)
Module 1: Introduction and Data Preprocessing (CO1 – Analyze) – 8 Theory Hours
Topics: Data mining overview, knowledge discovery process, data types, data cleaning, transformation, normalization, feature selection, data integration.
Module 2: Classification and Regression (CO2 – Analyze) – 8 Theory Hours
Topics: Supervised learning overview, decision trees, Naïve Bayes, K-NN, SVM, logistic regression, performance metrics (confusion matrix, precision, recall, F1-score, ROC).
Module 3: Clustering and Association Rule Mining (CO3 – Apply) – 8 Theory Hours
Topics: K-means, hierarchical clustering, DBSCAN, evaluation of clusters, Apriori and FP-

Growth algorithms, support, confidence, lift metrics.

Module 4: Predictive Analytics Tools and Applications (CO4 – Apply) – 6 Theory Hours

Topics: Predictive model deployment, cross-validation, overfitting, underfitting, time series basics, real-life applications in marketing, finance, healthcare.

Laboratory Experiments (15 Weeks / 30 Hours)

1. Data cleaning and preprocessing using Python or R.
2. Feature selection and transformation techniques.
3. Implement decision tree classifier and evaluate using metrics.
4. Apply Naïve Bayes and K-NN classifiers.
5. Perform logistic regression for binary classification.
6. Train and test SVM on real dataset.
7. Build a K-means clustering model and visualize clusters.
8. Implement hierarchical clustering and interpret dendrograms.
9. Apply DBSCAN for density-based clustering.
10. Extract association rules using Apriori algorithm.
11. Perform FP-Growth and analyze rule significance.
12. Cross-validation and hyperparameter tuning.
13. Build a predictive model on time series data.
14. Model deployment using Flask/Streamlit.
15. Mini project on end-to-end predictive analytics solution.

Textbooks:

- **T1:** Jiawei Han, Micheline Kamber, and Jian Pei, *Data Mining: Concepts and Techniques*, 3rd Edition, Morgan Kaufmann, 2011.
- **T2:** Trevor Hastie, Robert Tibshirani, and Jerome Friedman, *The Elements of Statistical Learning*, Springer, 2nd Edition.

Reference Books:

- R1: Ian H. Witten, Eibe Frank, Mark A. Hall, *Data Mining: Practical Machine Learning Tools and Techniques*, Elsevier.
- R2: Galit Shmueli, Nitin R. Patel, Peter C. Bruce, *Data Mining for Business Analytics*, Wiley.

Web Resources:

- [W1] https://www.kaggle.com/learn
- [W2] https://scikit-learn.org/stable/
- [W3] https://www.datacamp.com/

Course Code: DSC4004		**Course Title:** Big Data Analytics Tools and Techniques **Type of Course:** **Program Core** **Theory and Lab Integrated Course**	**L- T-P-C**	2	0	2	3
Version No.		2.0					
Course Pre-requisites		--					
Anti-requisites		**NIL**					

Course Description		This course is designed to provide the fundamental knowledge to equip students being able to handle real-world big data problems including the three key resources of Big Data: people, organizations and sensor. With the advancement of IT storage, processing, computation and sensing technologies. It helps the students to interpret the operational concepts of computer technology as well as performance enhancement.
Course Objective		The objective of the course is to familiarize the learners with the concepts of Big Data Analytics Tools and Techniques and attain **EMPLOYABILITY SKILLS** through **EXPERIENTIAL LEARNING** techniques
Course Outcomes		On successful completion of the course the students shall be able to: CO1: Understand managing big data using Hadoop analytical tools and technologies CO2: Understand map-reduce analytics using Hadoop and related tools CO3: Preparing for data summarization, query, and analysis. CO4: Applying data modeling techniques to large data sets CO5: Building a complete business data analytic solution
Course Content:		

Module 1	Introduction to Hadoop and HDFS	Assignment	Data Collection and Analysis		**8 Sessions**

Topics:

Meet Hadoop: Data, Data Storage and Analysis, Comparison with Other Systems: Relational Database Management Systems, Grid Computing, Volunteer Computing Hadoop Fundamentals Map Reduce A Weather Dataset: Data Format, Analyzing the Data with Unix Tools, Analyzing the Data with Hadoop: Map and Reduce, Java Map Reduce, Scaling Out: Data Flow, Combiner Functions, Running a Distributed Map Reduce Job, Hadoop Streaming , Characteristics of big data, Challenges in processing big data, Limitations of classical algorithms on big data

The Hadoop Distributed File system: The Design of HDFS, HDFS Concepts: Blocks, Name nodes and Data nodes, HDFS Federation, HDFS High-Availability, The Command-Line Interface, Basic File system Operations, Hadoop File systems Interfaces, The Java Interface, Reading Data from a Hadoop URL, Reading Data Using the File System API, Writing Data, Directories, Querying the File system, Deleting Data, Data Flow: Anatomy of a File Read, Anatomy of a File Write, Using Hadoop archives, limitations.

Module 2	YARN and Hadoop I/O	Assignment	Data Collection and Analysis		**8 Sessions**

Topics:

YARN Anatomy of a YARN Application Run: Resource Requests, Application Lifespan, Building YARN Applications, YARN Compared to Map Reduce, Scheduling in YARN: The FIFO Scheduler, The Capacity Scheduler, The Fair Scheduler, Delay Scheduling, Dominant Resource Fairness

Hadoop I/O: Data Integrity in HDFS, Local File System, Checksum File System, Compression and Input Splits, Using Compression in Map Reduce, Serialization, The Writable Interface, Writable Classes, Implementing a Custom Writable, Serialization Frameworks, File-Based Data Structures: Sequence File

Module 3	Map Reduce Applications	Case Study	Data analysis		**8 Sessions**

Topics:

Developing a Map Reduce Application: The Configuration API, Combining Resources, Variable Expansion, Setting Up the Development Environment, Managing Configuration, Generic Options Parser, Tool, and Tool Runner, Writing a Unit Test with MR Unit: Mapper, Reducer, Running Locally on Test Data, Running a Job in a Local Job Runner, Testing the Driver, Running on a Cluster, Packaging a Job, Launching a Job, The Map Reduce Web UI, Retrieving the Results, Debugging a Job, Hadoop Logs, Tuning a Job, Profiling Tasks, Map Reduce Workflows: Decomposing a Problem into Map Reduce Jobs, Job Control, Apache Oozie

	How Map Reduce Works: Anatomy of a Map Reduce Job Run, Job Submission, Job Initialization, Task Assignment, Task Execution, Progress and Status Updates, Job Completion, Failures: Task Failure, Application Master Failure, Node Manager Failure, Resource Manager Failure, Shuffle and Sort: The Map Side, The Reduce Side, Configuration Tuning, Task Execution: The Task Execution Environment, Speculative Execution, Output Committers				
Module 4	Map Reduce Types and Formats, Flume	Case Study	Data analysis		**10 Sessions**
	Topics: **Map Reduce Types, Input Formats**: Input Splits and Records Text Input, Binary Input, Multiple Inputs, Database Input (and Output) Output Formats: Text Output, Binary Output, Multiple Outputs, Lazy Output, Database Output **Flume** Installing Flume, An Example, Transactions and Reliability, Batching, The HDFS Sink, Partitioning and Interceptors, File Formats, Distribution: Agent Tiers, Delivery Guarantees, Sink Groups, Integrating Flume with Applications, Component Catalog				
Module 5	**Hive, Pig, Spark Analytical Tools**	Case Study	Data analysis		**10 Sessions**
	Topics: **Hive** Apache Hive with Hive Installation, Hive Data Types, Hive Table partitioning, Hive DDL commands, Hive DML commands, Hive sort by vs order by, Hive Joining tables **Pig** Installing and Running Pig, Execution Types, Running Pig Programs, Grunt, Pig Latin Editors, An Example: Generating Examples, Comparison with Databases, Pig Latin: Structure, Statements, Expressions, Types, Data Processing Operators: Loading and Storing Data, Filtering Data, Grouping and Joining Data, Sorting Data, Combining and Splitting Data. **Spark** An Example: Spark Applications, Jobs, Stages and Tasks, A Java Example, A Python Example, 20082020 / 31 Resilient Distributed Datasets: Creation, Transformations and Actions, Persistence, Serialization, Shared Variables, Broadcast Variables, Accumulators, Anatomy of a Spark Job Run, Job Submission, DAG Construction, Task Scheduling, Task Execution, Executors and Cluster Managers: Spark on YARN				
	List of Laboratory Tasks: 1. (i) Perform setting up and Installing Hadoop in its two operating modes: • Pseudo distributed, • Fully distributed. (ii) Use web based tools to monitor your Hadoop setup. **Level 1:** Programming assignment to install the Hadoop environment tools. 2. (i) Implement the following file management tasks in Hadoop: • Adding files and directories • Retrieving files • Deleting files (ii) Benchmark and stress test an Apache Hadoop cluster **Level 1:** Programming assignment to maintain the Hadoop Distributed File System. 3. Run a basic Word Count Map Reduce program to understand Map Reduce Paradigm. • Find the number of occurrence of each word appearing in the input file(s) • Performing a Map Reduce Job for word search count (look for specific keywords in a file) **Level 1:** Programming scenario to use map reduce programming to perform the analysis. **Level 2:** Programming assignment to analyze the data for any given data file. 4. Stop word elimination problem:				

Input:

- A large textual file containing one sentence per line
- A small file containing a set of stop words (One stop word per line)

Output:

A textual file containing the same sentences of the large input file without the words appearing in the small file.

5. Write a Map Reduce program that mines weather data. Weather sensors collecting data every hour at many locations across the globe gather large volume of log data, which is a good candidate for analysis with Map Reduce, since it is semi structured and record-oriented. Data available at: https://github.com/tomwhite/hadoopbook/tree/master/input/ncdc/all.

- Find average, max and min temperature for each year in NCDC data set?
- Filter the readings of a set based on value of the measurement, Output the line of input files associated with a temperature value greater than 30.0 and store it in a separate file.

Level 2: Programming assignment to analyze the social media data for business analytics.

6. For Purchases.txt Dataset , instead of breaking the sales down by store, give us a sales breakdown by product category across all of our stores.

- What is the value of total sales for the following categories?

  i. Toys
  ii. Consumer Electronics

- Find the monetary value for the highest individual sale for each separate store
  What are the values for the following stores?
  i. Reno
  ii. Toledo
  iii. Chandler
- Find the total sales value across all the stores, and the total number of sales.

Level 2: Programming assignment to analyze and find the maximum sales, minimum sales and average sales in each store.

7. Install and Run Pig then write Pig Latin scripts to sort, group, join, project, and filter your data.

Level 1: Programming scenarios to perform the grouping, filtering and Joining.

8. Write a Pig Latin scripts for finding TF-IDF value for book dataset (A corpus of eBooks available at: Project Gutenberg)
Level 2: Programming Assignment to analyze the data from the given text file using Pig latin script.

9. Install and Run Hive then use Hive to create, alter, and drop databases, tables, views, functions, and indexes.
Level 1: Programming scenario to analyze the data from the given text file to perform SQL operations.

10. Install, Deploy & configure Apache Spark Cluster. Run apache spark applications using Scala.
Level 1: Programming scenario to analyze a dataset using spark.

11. Data analytics using Apache Spark on Amazon food dataset, find all the pairs of items frequently reviewed together.

Write a single Spark application that:

- Transposes the original Amazon food dataset, obtaining a Pair RDD of the type:
- Counts the frequencies of all the pairs of products reviewed together;

	• Writes on the output folder all the pairs of products that appear more than once and their frequencies. The pairs of products must be sorted by frequency. **Level 2:** Programming assignment to analyze the data using spark.
	Targeted Application & Tools that can be used: • **Business Analytical Applications** • **Social media Data Analysis** • **Predictive Analytics** • **Government Sector for analyzing the data** • **Improve the business through analytics** **Tools: Hadoop Framework tools like map reduce, Hive, Hbase, Spark, Pig, Flume.**
	Project work/Assignment:
	After completion of each module a programming based Assignment/Assessment will be conducted. A scenario will be given to the student to be developed as a data analysis application. On completion of Module 5, student will be asked to develop a project for Data Analysis.
	Text Book T1. Hadoop: The Definitive Guide Tom White O'Reilley Third Edition, 2012
	References R1.SPARK: The Definitive Guide MateiZaharia and Bill Chambers Oreilly 2018 R2.Apache Flume: Distributed Log Collection for Hadoop . D'Souza and Steve Hoffman Oreilly 2014 **Weblinks** W1.https://presiuniv.knimbus.com/user#/home W2. Data Analytics: What It Is, How It's Used, and 4 Basic Techniques (investopedia.com)
	Topics relevant to "EMPLOYABILITY SKILLS ": Real time application development using Hadoop Ecosystem tools. for developing **EMPLOYABILITY SKILLS** through **EXPERIENTIAL LEARNING** techniques. This is attained through assessment component mentioned in course handout

Course Code: DSC4011	**Course Title:** **Data Science with Cloud Computing** **Type of Course:** **Discipline Elective** **Theory Only**			**L- T-P- C**	3	0	0	3
Version No.		2.0						
Course Pre-requisites		--						
Anti-requisites		**NIL**						
Course Description		This course introduces a new Transformative, more collaborative way of doing Data Science. It helps in understanding End to End Data pipelines, Ingesting Data in a serverless way and working our way through Data Exploration, Dashboards, and Streaming Data all the way to training and making an operational Machine Learning Model.						
Course Objective		The objective of the course is to familiarize the learners with the concepts of **Data Science with Cloud Computing** and attain **EMPLOYABILITY SKILLS** through **PARTICIPATIVE LEARNING** techniques						
Course Outcomes		On successful completion of the course the students shall be able to: CO1.Define Data Science and its fundamentals and the process in Data Science. CO2.Explain the process of Ingesting Data into the Cloud Platform. CO3.Analyze real-world problems with Accuracy. CO4.Demonstrate the overall organization of Data and Storage.						
Course Content:								
Module 1	**Making Better Decisions Based on Data**	**Assignment**	**Case Study**			**10 Sessions**		
	Topics: Many Similar Decisions, Role of Data Engineers, The Cloud Makes Data Engineers Possible, The NaN value, Series CRUD, Series Indexing, The Cloud Turbocharges Data science, Airline on Time Performance Data, Scheduling Monthly Downloads.							
Module 2	**Creating Compelling Dashboards**	**Assignment**	**Case Study**			**10 Sessions**		
	Topics: Explain your Model with Dashboards, Loading Data into google Cloud SQL, Creating Google cloud Instance, Interacting with Google cloud Platform, Maximum Likelihood Estimation (MLE)							
Module 3	**Streaming Data: Publication and Ingest**	**Assignment**	**Case Study**			**10 Sessions**		
	Topics: Designing the Event Feed, Time Correction, Apache Beam/Cloud Dataflow, Publishing an							

Event Stream to Cloud Pub/Sub, Real Time Stream processing, Interactive Data Exploration, Exploratory Data Analysis, Loading Flights Data into Big Query, Arrival Delay conditioned on Departure Delay, Evaluating the Model. Time Series Analysis

Module 4	Cloud Dataproc	Assignment	Case Study		10 Sessions

Topics:
Bayes Classifier on Cloud Dataproc, Map Reduce and Hadoop Eco System, Quantization using Spark SQL, Bayes Classification using Pig

Targeted Applications & Tools that can be used:

Targeted Industries like Banking, Transport, e-commerce, healthcare and many more are using data science to make optimal Decisions. The usage of data science helps in rising sales. It can explore historic data, make comparisons and analyses of the market and provide recommendations.
Target Jobs Data Scientist, Data Architect, Data Engineer, Statistician.
Tools:

- Apache Spark
- Jupyter
- Weka

Project work/Assignment:

Mini Project:

Walmart Sales Forecasting in Cloud

- Predict the sales across various departments in each store.
- Predict the effect of markdowns on the sales during the holiday seasons.

Term Assignments:

Consider a Dataset on Bird communities that needs to be analyzed. The data has three columns, a date, a common name, and a count of the number of individuals.

- Count the total number of individuals of each species that were seen in each data file.
- Sort based on the total number of individuals.

Text Book
T1. "Data Science on the Google Cloud Platform: Implementing End-to-End Real-Time Data Pipelines: From Ingest to Machine Learning"-Valiappa Lakshmanan,1st Edition, January 2018.
T2. "Data Analysis in The Cloud"- Domenico Talia ,1st Edition, September 2015

References
R1. Doing Data Science, Straight Talk from the Frontline. O'Reilly. 2014.

Weblinks
W1.https://presiuniv.knimbus.com/user#/home

	W2.https://www.geeksforgeeks.org/why-cloud-computing-is-important-in-data-science/
	Topics relevant to " EMPLOYABILITY SKILLS ": Data Extraction, Data wrangling for developing **Employability Skills** through **Participative Learning techniques**. This is attained through assessment component as mentioned in course handout.

<table>
<tr><td>Course Code:
DSC4012</td><td colspan="4">Course Title: Data Security and Access Control

Type of Course: Discipline Elective
Theory Only</td><td>L- T-P-C</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td>Version No.</td><td colspan="9">2.0</td></tr>
<tr><td>Course Pre-requisites</td><td colspan="9">--</td></tr>
<tr><td>Anti-requisites</td><td colspan="9">NIL</td></tr>
<tr><td>Course Description</td><td colspan="9">This course describes fundamental issues and problems in data security and provides technical solutions or facets to the problem of achieving data security. The course also deals with the security of statistical databases, discusses authorization systems, and covers the fundamental ideas of cryptography.</td></tr>
<tr><td>Course Objective</td><td colspan="9">The objective of the course is to familiarize the learners with the concepts of Data Security and Access Control and attain EMPLOYABILITY SKILLS through Participative Learning techniques.</td></tr>
<tr><td>Course Outcomes</td><td colspan="9">On successful completion of the course the students shall be able to:
CO1: Describe the basic concepts of a Data Security
CO2: Apply appropriate techniques for security Algorithms
CO3: Explain the Access Controls mechanisms
CO4: Simulate data security algorithms for achieving access control</td></tr>
<tr><td>Course Content:</td><td colspan="9"></td></tr>
<tr><td>Module 1</td><td>Fundamentals of Data Security</td><td>Assignment</td><td>Algorithms</td><td></td><td colspan="5">8 Sessions</td></tr>
<tr><td colspan="10">Topics: Introduction to Data Security, Confidentiality, Integrity, Availability, Visibility, Automation, Monitoring, Models and Methodology, and The Security Problem in Computing. The Data Encryption Standard</td></tr>
<tr><td>Module 2</td><td>Data Security Techniques</td><td>Assignment/ Case Study</td><td>Presentation</td><td></td><td colspan="5">10 Sessions</td></tr>
<tr><td colspan="10">Topics: Introduction, data masking, data erasure, and backup storage, Anti-malware protection, viruses and other malicious code, Security in Key specified model, Security in Characteristic specified model, File Protection Mechanisms</td></tr>
<tr><td>Module 3</td><td>Authorization Mechanisms in Data Security</td><td>Assignment/ Case Study</td><td>Coding</td><td></td><td colspan="5">12 Sessions</td></tr>
<tr><td colspan="10">Topics: Introduction, concept of Un-decidability, Authorization Systems with Tractable Safety Problem, Authorization Systems with Tractable Safety Problem, Grammatical Authorization Systems, Threats in Network, Network Security Controls</td></tr>
<tr><td>Module 4</td><td>An Overview of Data Security Tools, Data Security Policies</td><td>Assignment/ Case Study</td><td>Simulation of DS tools</td><td></td><td colspan="5">8 Sessions</td></tr>
<tr><td colspan="10"></td></tr>
</table>

	Topics: Introduction to tools available for Data Security, Demonstration of Security features in Linux platform, simulation using more than two computers, demonstration of data leakage during transmission, GDPR (General Data Protection Regulation), Comparative study with India regulation, Data Privacy Act, Role Based Access Control, Organizational Security policies.
	Targeted Applications & Tools that can be used: Anomaly Deduction, Inclusion Prevention Systems, Firewall, Email Security **Tools:** SAGE Mathematical Library package, VPN
	Assignment:
	Term Assignments: 1. Implement Cryptographic algorithms using SAGE 2. Comparative Study on Various Data Security Tools 3. Case Study on GDPR - General Data Protection Regulation 4. Identify Data Leakage in LINUX environment using Authorization Mechanisms
	Text Book T1. Data Privacy and Security, David Solomon, Springer, T2. Principles of Data Security, Ernst L. Leiss, Plenum Press. New York And London
	References R1. Intelligence and Security Informatics for International Security, Chen, Hsinchun, Springer Publication 2006 R2. Certified Information Security Professional (CSIP) web portal **Weblinks** W1.https://presiuniv.knimbus.com/user#/home W2. https://www.datasunrise.com/professional-info/what-is-access-control/
	Topics relevant to "EMPLOYABILITY SKILLS": **":** Email Security, Web Security, GDPR (General Data Protection Regulation), Grammatical Authorization Systems for developing Employability Skills through Participative Learning techniques. This is attained through assessment component mentioned in course handout.

Course Code: DSC4015	**Course Title: IOT Data Analytics** **Type of Course: Discipline Elective Theory Only**	**L- T-P-C**	3	0	0	3
Version No.	2.0					
Course Pre-requisites	--					
Anti-requisites	**NIL**					

Course Description		This course helps in understanding the context of analytics in IoT data. Strategies to collect IoT data in order to enable analytics. Skills learnt will enable to understand the tradeoffs in streaming and batch processing. Data science techniques such as machine learning, deep learning, and forecasting are applied on IoT data. This course also teaches how to implement machine learning methods and ARIMA forecasting on IoT data. Deep learning will be described along with a way to get started experimenting with it on AWS.			
Course Objective		The objective of the course is to familiarize the learners with the concepts of IoT Data Analytics and attain **EMPLOYABILITY SKILLS** through **Problem Solving** Methodologies.			
Course Outcomes		On successful completion of the course the students shall be able to: CO1: Discuss the challenges of IoT Analytics. CO2: Apply strategies and techniques to collect IoT data. CO3: Apply data science techniques on IoT data			
Course Content:					
Module 1	IoT analytics, challenges, devices and networking protocols	Assignment	Data Analysis task		**12 Sessions**
	Topics: Defining IoT Analytics and Challenges Defining IoT Analytics. IoT analytics challenges, Core IoT Functional Stack, Functional blocks of an IoT ecosystem IoT Devices and Networking Protocols IoT devices Networking basics IoT networking connectivity protocols IoT networking data messaging protocols Message Queue Telemetry Transport (MQTT) Hyper-Text Transport Protocol (HTTP) Data Distribution Service (DDS)				
Module 2	Data – Strategies, Techniques and Exploring IoT Data	Assignment	Analysis, Data Collection		**12 Sessions**
	Topics: Collecting All That Data - Strategies and Techniques Designing data processing for analytics Applying big data technology to storage Apache Spark for data processing Exploring IoT Data Exploring. Data analytics tools				
Module 3	Data Science for IoT Analytics	Case Study	Data analysis task		**13 Sessions**
	Topics: Feature engineering with IoT data Validation methods Understanding the bias–variance trade off Comparing different models to find the best fit Random Forest models Gradient Boosting Machines Anomaly detection, Forecasting, scaling issues.				
	Targeted Application & Tools that can be used: Employment opportunities are available in Companies like Hexaware, Episteme, Randstad. Siemens, Accenture etc. as IoT Data Engineer Tools R Python Microsoft Azure Stream Analytics.				

	AWS IoT Analytics. SAP Analytics Cloud. Oracle Stream Analytics and Oracle Edge Analytics.
	Project work
	Mini Project: Develop a IoT application for real time data analysis of manufacturing sector. The automated IoT Analytics should aid in using real time data to watch out for certain patterns and send alerts to the concerned departments. It should enable smart manufacturing.
	Text Book T1."Analytics for the Internet of things (IoT)", Andrew Minteer, Packt, 2017
	References R1.WInternet of Things and Big Data Analytics for Smart Generation, Valentina E Balas, Springer **Weblinks** W1.https://presiuniv.knimbus.com/user#/home W2.https://www.orientsoftware.com/blog/iot-data-analytics/
	Topics relevant to "EMPLOYABILITY SKILLS": Processing geospatial IoT Data, protocols Message Queue Telemetry Transport (MQTT) Hyper-Text Transport Protocol (HTTP) Constrained Application Protocol (CoAP) Data Distribution Service (DDS), Random Forest models Gradient Boosting Machines Anomaly detection for developing Employability Skills through Problem Solving methodologies. This is attained through assessment component mentioned in course handout.

Course Code: DSC4016	**Course Title: Probabilistic graph Models** **Type of Course: Discipline Elective Theory Only**		**L- T-P-C**	3	0	0	3
Version No.		2.0					
Course Pre-requisites		--					
Anti-requisites		**NIL**					
Course Description		Probabilistic graphical models are used to model stochasticity (uncertainty) in the world and are extremely popular in AI and machine learning. The course will cover two classes of graphical models: Bayesian belief networks (also called directed graphical models) and Markov Random Fields (undirected models). After introducing the two frameworks the course will focus on recent advances in inferences and learning with graphical models, including topics such as loopy belief propagation, variational approximations, conditional Markov random fields and others.					
Course Objective		The objective of the course is to familiarize the learners with the concepts of **Probabilistic graph Models** and attain EMPLOYABILITY SKILLS through PARTICIPATIVE LEARNING techniques					

Course Outcomes		On successful completion of the course the students shall be able to: CO1: Apply key concepts of Statistics to solve problems. CO2: Analyze the properties of distributions encoded by graphs CO3: Illustrate Inference in graphic models CO4: Illustrate Learning in graphic models			
Course Content:					
Module 1	Fundamentals of Probability and Graph Theory	Assignment	Understanding all standard probability distributions		**9 Sessions**
	Topics: Fundamentals of Statistics and Probability, Conditional Probability, Conditional Independence, Joint Distributions, Baye's Theorem, Gaussians rule, Probability Distributions, Fundamentals of Graph Theory - Paths, Cliques, Sub-graphs, Cycles and Loops.				
Module 2	Graphical Models	Assignment	Construction of Markov chain model for real time problems		**9 Sessions**
	Topics: Directed Models: Bayesian Network; Undirected Models: Markov Random Fields; Parameterization of MRFs, Independencies, Duality and optimality, Non parametric Bayes hierarchical models.				
Module 3	Inference in Graphical Models	Assignment	Study about some problems based on Monte Carlo method		**9 Sessions**
	Topics: Inference in Graph Models, Variable Elimination; Belief Propagation, Sampling Methods: Markov Chain Monte Carlo, Convexity and optimization, Hidden Markov Model, Viterbi Algorithm.				
Module 4	Learning in Graphical Models	Assignment	Applications of Naïve Bayes Classifier		**10 Sessions**
	Topics: Learning in Graph Models, Maximum Likelihood Estimation, Naïve Bayes Classifier, Conditional Random Fields, constrained optimization problem				
	Targeted Application & Tools that can be used: Targeted employment sector is to acquire knowledge to analyze the given problem to frame Probabilistic graphical models which are a powerful framework for representing complex domains using probability distributions, with numerous applications in machine learning, computer vision, natural language processing and computational biology. **Tools:** • Python • HUGIN Tool for Learning Bayesian Networks • MATLAB Toolbox for Bayesian net				
	Assignment:				

	Term Assignments: • **Analysis and Application of Bayesian Network to real time problems** Understanding the given problem, analyze accordingly to apply Bayesian network and convert the problem in a Bayesian Network. The answering the required queries. • **A short survey of the Monte Carlo Method** Study and analyze few realistic problems to apply Monte Carlo Technique to answer the solution of the problem. • **A short survey of the Markov Chain & Hidden Markov Method** Study and analyze few realistic problems to convert into Markov chain & Hidden Markov to answer the required problem.
	Text books(s) T1. S. Lauritzen. Graphical Models. Oxford University Press, 1996. T2. David J.C. Mackay. Information theory, inference, and learning algorithms. Cambridge, UK: Cambridge University Press 2003. **References(s)** R1.https://towardsdatascience.com/introduction-to-probabilistic-graphical-models-b8e0bf459812. **Weblinks** W1.https://presiuniv.knimbus.com/user#/home W2.https://home.cs.colorado.edu/~mozer/Teaching/syllabi/ProbabilisticModels//
	Topics relevant to development of "EMPLOYABILITY SKILLS": Conditional Independence , Markov Random Fields; Parameterization of MRFs, Independencies,, Metropolis Hastings Algorithm, Hidden Markov Model, Viterbi Algorithm for developing Employability Skills through Participative Learning techniques. This is attained through assessment component mentioned in course handout

Course Code: DSC4017	Course Title: **Social Network Analysis** Type of Course: **Discipline Elective Theory Only**		L- T-P- C	3	0	0	3
Version No.		2.0					
Course Pre-requisites		--					
Anti-requisites		**NIL**					
Course Description		The rapid growth of social media has given the mass consumers a powerful tool to create knowledge and propagate opinions. At the same time, social media has created an unprecedented opportunity for companies to engage real-time interactions with consumers. In addition, the size and richness of social media data has provided companies an unusually deep reservoir of consumer insights to transform the business and marketing operations. The social media analytics course will enable students to grasp the analytics tools to leverage social media data. The course will introduce tools such as engagement analytics, sentiment analysis, topic modeling, social network analysis, identification of influencers and evaluation of social media strategy.					
Course Objective		The objective of the course is to familiarize the learners with the concepts of **Social Network Analysis** and attain EMPLOYABILITY SKILLS through PROBLEM SOLVING techniques					
Course Outcomes		**On successful completion of this course the students shall be able to:** CO1: Interpret the social network landscape and appreciate the importance of analytics in business. CO2: Apply appropriate native analytics and measurement tools to analyze data in different social platforms CO3: Use Natural Language Processing for efficient mining of web data CO4: Demonstrate meaningful insights with actionable and strategic recommendations.					
Course Content:							
Module 1	**Network Science**	Quiz/Assignment	Analysis				**9 Sessions**
	Topics: Introduction to semantic web, limitation of current web, Central Measures, Community Analysis, CPM, Homophily and Triadic Closure, Affiliation Networks, Schelling model of Segregation, Current Social Media landscape, working environment, Getting analyzing and visualizing the data, Getting started with the toolset, Need for SMA, Applications of SMA in different areas. Connecting, Capturing and cleaning of Social Data. Social network analysis of social and behavioral sciences APIs in nutshell, Introduction to authenticate techniques, Parsing API outputs, Basic cleaning techniques. Exploring GitHub's API, Analyzing GitHub Interest Graphs, Computing Graph Centrality Measures.						
Module 2	**Analyzing Social graphs and Sentiment**	Quiz	Project Development				**10 Sessions**
	Topics: Modeling and aggregating social network data, Exploring Facebook's Social Graph API, Open Graph Protocol, Analyzing Social Graph Connections, Mining your posts, Facebook Pages. Exploring Twitter's API, Analyzing Twitter using sentiment analysis, Frequency Analysis,						

	Examining Patterns in Retweets.				
Module 3	**Mining web pages**	Assignment	Project Development		**11 Sessions**
	Topics: Scraping, Parsing and Crawling the Web: BFS in Web Crawling, Discovering Semantics by Decoding Syntax: NLP Illustrated Step-by-Step, Sentence Detection in Human Language Data, Document Summarization, Entity-Centric Analysis: A Paradigm Shift, Summarizing Human Language Data, Quality of Analytics for Processing Human Language Data, trust models based on subjective logic Campaigns and Consumer Reaction Analytics on YouTube: Structured and Unstructured, Scope and Process, Getting the data, Data pull, Data processing and Data analysis, Attack spectrum and counter measures.				
Module 4	**Recommender Systems and SEO**	Quiz	Group Discussion		**8 Sessions**
	Topics: Content-Based Recommendation and Collaborative Filtering, introduction to SEO, Keyword research Process, avoid negative SEO, Search Engines, Google PageRank, IBM HITS,				
	Targeted Application & Tools that can be used: The applications of Social Media Analytics have been seen in industrial sector, sports and games, local governments services, tourism and hospitality services, politics, social issues, disaster management, community development issues, commerce and business applications, fashion industry, agricultural activities, online media, medical and health related services as well as supplier chain services. **Tools**: Google Colab or Jupyter Notebook(Anaconda).				
	Project work				
	On completion of all Modules, students will be given a Mini Project to build a deep learning model for a given application. Sample mini projects include: **Twitter Summaries** Twitter is famous for its character-limited posts. We can use this social media platform for an innovative summary-writing project. Consolidate the takeaways from a topic or reading discussed. Students should be able to understand the text, coherently organize the points and capture the central idea with 280 words, which is the character limit on Twitter. **Hashtag activism** Information and communication technologies provide a tremendous tool for spreading awareness and highlighting issues that may not be adequately represented in the mainstream media. Hashtag activism, in particular is concerned with driving social media traffic to oft-neglected topics. We can devise a project-based activity to teach our students about social justice, human rights, equality etc.				
	Text Book(s): **T1.Mathew A. Russell, "*Mining the Social Web*", O'Reilly, 3rd Edition, 2019.**				
	Reference(s): **R1.Marco Bonzanini, "*Mastering Social Media Mining with Python*", PacktPub, 2016.** **Weblinks** W1.https://presiuniv.knimbus.com/user#/home W2.https://onlinecourses.nptel.ac.in/noc22_cs117/preview				
	Topics relevant to "EMPLOYABILITY SKILLS: **Recommender Systems and SEO** for				

	developing Employability Skills through PROBLEM SOLVING techniques. This is attained through assessment component mentioned in course handout

<table>
<tr><td>Course Code:
DSC4002</td><td colspan="3">Course Title: Data Analytics and Visualization

Type of Course: Program Core
Theory and Laboratory Integrated Course</td><td>L-T-P-C</td><td>2</td><td>0</td><td>2</td><td>3</td></tr>
<tr><td>Version No.</td><td></td><td colspan="7">2.0</td></tr>
<tr><td>Course Pre-requisites</td><td></td><td colspan="7">--</td></tr>
<tr><td>Anti-requisites</td><td></td><td colspan="7">NIL</td></tr>
<tr><td>Course Description</td><td></td><td colspan="7">The Course consists of two parts where first Part covers advanced analytics that covers topics necessary to give businesses greater insight into their data than they could ordinarily, and the Second Part covers data visualization concepts. Primary concepts include machine learning, data mining, predictive analytics, location analytics, big data analytics, and location intelligence. Visualization for Time series, Geolocated data, Correlations, connections, Hierarchies, networks, and interactivity.</td></tr>
<tr><td>Course Objective</td><td></td><td colspan="7">The objective of the course is to familiarize the learners with the concepts of Data Analytics and Visualization and attain EMPLOYABILITY SKILLS through PARTICIPATIVE LEARNING techniques</td></tr>
<tr><td>Course Out Comes</td><td></td><td colspan="7">On successful completion of the course the students shall be able to:
CO1: Analyze data by performing Exploratory Data Analysis.
CO2: Apply techniques of Machine Learning to build Generalized Predictive Models.
CO3: Explain basic concepts of Data Visualization.
CO4: Apply principles of Data Visualizations to provide insights from data.</td></tr>
<tr><td>Course Content:</td><td></td><td colspan="7"></td></tr>
<tr><td>Module 1</td><td colspan="2">Data Analytics</td><td>Assignment</td><td colspan="2">Analysis, Data Collection</td><td></td><td colspan="2">11 Sessions</td></tr>
<tr><td colspan="9">Topics:
Characteristics and types of data, Types of Analytics, Location Analytics, Working with Geospatial Data, Feature Engineering and Selection, Dimensionality Reduction Techniques, Common challenges faced during analysis</td></tr>
<tr><td>Module 2</td><td colspan="2">Advanced Analytics</td><td>Case Study</td><td colspan="2">Analysis, Data Collection, Programming</td><td></td><td colspan="2">13 Sessions</td></tr>
<tr><td colspan="9">Topics:
Statistical methods for Data Analytics, Advance topics in Supervised and Unsupervised Machine Learning: Cluster Analysis, Hyper-Parameter Tuning, Measuring Performance of the Models, Model Selection, Data Mining techniques.</td></tr>
<tr><td>Module 3</td><td colspan="2">Introduction to Data Visualization</td><td>Assignment</td><td colspan="2">Analysis, Data Collection</td><td></td><td colspan="2">9 Sessions</td></tr>
<tr><td colspan="9">Topics:
Importance of analysis and visualization in the era of data abundance, Fundamentals of Data Visualization, Human Perception, Basic plotting techniques, Interaction concepts, Visualization techniques for Time Oriented data, Introduction to Data Visualization Tools</td></tr>
<tr><td>Module 4</td><td colspan="2">Application - Data Visualization</td><td>Case Study</td><td colspan="2">Analysis, Data Collection,</td><td></td><td colspan="2">14 Sessions</td></tr>
</table>

			Programming		

	Topics: Designing effective Visualizations, Advanced Visualization Tools, Visualizing Geospatial Data, Document Visualization, Visualization Systems, Evaluating Visualizations, Visualization Benchmarking. Use cases of data visualization.
	List of Laboratory Tasks: **Experiment No 1: Exploratory Data analysis** **Level 1:** Demonstration of Tools to implement EDA **Level 2:** Use the Dataset to analyze and summarize data, analyze anomalies, analyze Outliers, and Missing Value Treatment **Experiment No. 2: Dimensionality Reduction Techniques** **Level 1:** Implement DR Technique(s) **Experiment No. 3: Machine Learning Methods** **Level 1:** Implement Supervised Learning Techniques for the given dataset **Level 2:** Implement Un-Supervised Learning Techniques for the given dataset and Cluster Analysis **Experiment No. 4: Measure the Performance of the Models** **Level 1**: Perform Model Selection **Level 2**: Regularize the model **Experiment No. 5: Introduction to Data Visualization Tools** **Level 1**: Implement Basic plotting techniques **Experiment No. 6: Time Oriented data** **Level 1:** Visualization techniques for Time Oriented data **Experiment No. 7: Trees, Graphs, Networks** **Level 1:** Visualization techniques for Trees, Graphs, Networks **Experiment No. 8: Advanced Visualization Tools** **Level 1:** Design effective Visualizations for the given scenario **Level 2**: Implement Visualizing of Geospatial Data and Document Visualization **Experiment No. 9: Analyze Visualization Systems** **Level 1:** Analyze Visualization Systems
	Targeted Application & Tools that can be used:

	Data visualization is the graphical representation of information and data. By using visual elements like charts, graphs, and maps, data visualization tools provide an accessible way to see and understand trends, outliers, and patterns in data. In the world of Big Data, data visualization tools and technologies are essential to analyze massive amounts of information and make data-driven decisions. **Tools**: 2. R Programming 3. Python 4. Tableau 5. SAS 6. Excel 7. RapidMiner 8. IBM Cognos Analytics 9. Microsoft Power BI
	Project work:
	After completion of each module a Data analysis or programming based Assignment/Assessment will be conducted. **Mini Project:** Perform exploratory data analysis on a given dataset and provide insights on the same. **1. Crunchbase** – Find business information about private and public companies. You can look up how many investments they had, who the founding members are, and if they had any mergers or acquisitions. **2. Glassdoor Research** – Glassdoor offers data related to employment. You can, for example, figure out how much you can save by retaining employees. **3. Open Corporates** – Open Corporates is the largest open database of companies and company data in the world. Used by banks and governments, they pride themselves on having the most accurate data. 4. **FBI Uniform Crime Reporting –** The Uniform Crime Reporting compiles statistical crime reports, publications, and data points from thousands of cities, universities, states, and federal law enforcement agencies. 5. **Uppsala Conflict Data Program** – The Uppsala Conflict Data Program (UCDP) provides data on organized crime and civil war around the world. 6. **National Institute on Drug Abuse** – The National Institute on Drug Abuse (NIDA) monitors the prevalence and trends regarding drug abuse in the United States. 7. **DBpedia** – DBpedia aims to make Wikipedia's information easily searchable via SPARQL queries or by downloading their information directly. For instance, you can search for NBA players born in the 80s, in cities with more than 1M inhabitants. 8. **Google Trends** – Google Trends allows you to look at what's going on in the world. It gives you data about what's becoming popular, and how much people are searching for a particular term. 9. **Instagram API** – Facebook allows you to use Instagram's API to quickly access comments, metadata, and metrics. 10. **Comtrade** – Official trade in goods and services data sets managed by the UN COMTRADE database. There are data visualization tools and an API and other extraction tools available. 11. **Datahub – Stock Market** – From gold prices, NASDAQ listings, to S&P 500 companies, you'll find it all on datahub.io 12. **Global Financial Data** – Global Financial Data gives you exactly what it says on the tin; data about the finances of the world. Ranges from real estate, global macro data, to market data. 13. **IMF Data** – The IMF, or International Monetary Fund, is an organization that aims to foster monetary collaboration between countries. You can find data on trade, government finance, and financial development.

	14. **The Atlas of Economic Complexity** – The Atlas of Economic Complexity provides data about global trade dynamics over time. Want to know the quantity of textiles China exported to South Korea? Easy. 15. **World Bank** – Not only does the World Bank provide financial data about countries, but it also provides data on education and health. 16. **Financial Times Data** – Here you'll find cold, hard numbers about the different markets in the world. Data include fluctuations in currency, yield rates of bonds, and commodity prices.
	Text Book T1. Wilke, Claus O. Fundamentals of data visualization: a primer on making informative and compelling figures. O'Reilly Media, 2019. T2. Ward, Grinsten, Keim. Interactive Data Visualization: Foundations, Techniques, and Applications, A K Peters/CRC Press,2nd Edition, 2015
	References **R1.** Mohammed J. Zaki, and Wagner Meira Jr., "Data Mining and Analysis: Fundamental Concepts and Algorithms", Cambridge University Press, 2016 R2. I.H. Witten and E. Frank, Data Mining: Practical Machine learning tools and techniques Morgan Kaufmann publishers; 3rd Edition, 2011 **Weblinks** W1.https://presiuniv.knimbus.com/user#/home W2. https://www.geeksforgeeks.org/short-note-on-data-visualization/
	Topics relevant to "EMPLOYABILITY SKILLS": Real time decision-making application development using Data visualization tools for EMPLOYABILITY SKILLS through Participative Learning techniques. This is attained through assessment component mentioned in course handout.