B.S. Abdur Rahman Crescent Institute of Science & Technology

Deemed to be University u/s 3 of the UGC Act, 1956

Regulations 2019

Curriculum and Syllabi

(Amendments updated upto December 2020)

# M.Tech.
# (Data Science)

B.S. Abdur Rahman Crescent Institute of Science & Technology
Deemed to be University u/s 3 of the UGC Act, 1956

# REGULATIONS 2019

# CURRICULUM AND SYLLABI (I Semester)

**(Amendments updated upto December 2020)**

## M.TECH.

## DATA SCIENCE

## VISION AND MISSION OF THE INSTITUTION

### VISION

B.S.Abdur Rahman Crescent Institute of Science and Technology aspires to be a leader in Education, Training and Research in multidisciplinary areas of importance and to play a vital role in the Socio-Economic progress of the Country in a sustainable manner.

### MISSION

- To blossom into an internationally renowned Institute.
- To empower the youth through quality and value-based education.
- To promote professional leadership and entrepreneurship.
- To achieve excellence in all its endeavors to face global challenges.
- To provide excellent teaching and research ambience.
- To network with global Institutions of Excellence, Business, Industry and Research Organizations.
- To contribute to the knowledge base through Scientific enquiry, Applied Research and Innovation.

## DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

## VISION AND MISSION

### VISION

The vision of the Department of Computer Science and engineering is to impart quality education, inculcate professionalism and enhance the problem solving skills of the students in the domain of Computer Science and Engineering with a focus to make them industry ready, involve in possible areas of research, to pursue and have continual professional growth.

### MISSION

- To equip the students with strong fundamental concepts, analytical capability, programming and problem solving skills.
- To create an academic environment conducive for higher learning through faculty training, self learning, sound academic practices and research endeavors.
- To provide opportunities in order to promote organizational and leadership.
- Skills in students through various co-curricular and extra – curricular activities.
- To make the students industry ready and to enhance their employability through training and internships.
- To improve department industry collaboration through interaction including participation in professional society activities, guest lecturers and industrial visit.

## PROGRAMME EDUCATIONAL OBJECTIVES AND OUTCOMES

### M. Tech. (Data Science)

**Programme Educational Objectives:**

- Applying the knowledge acquired in the Computational models, Knowledge Engineering to develop intelligent and Smart systems for the industrial problems.

- Design solutions for real world problems that involve acquiring variety of data from multiple sources using Data Science.

- Imbibing a scientific perspective to pursue research in Artificial Intelligence and Data Science using Mathematical, Engineering, and Computational tools.

**Programme Outcomes:**

On successful completion of the programme, the graduates will be able to

- Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- Identify, formulate, research literature, and analyses complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- Use research –based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of the information to provide valid conclusions.

- Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
- Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

**PROGRAMME SPECIFIC OUTCOMES**

- Develop an in-depth knowledge and acquire skill sets on mathematical, statistical, and data science techniques
- To use software tools for data storage, analysis and visualization for solving real world problems.

# B.S. ABDUR RAHMAN CRESCENT INSTITUTE OF SCIENCE & TECHNOLOGY, CHENNAI – 600 048.

## REGULATIONS - 2019 FOR

## M.Tech. / MCA / M.Sc. / M.Com. DEGREE PROGRAMMES

***(Under Choice Based Credit System)***

## 1.0 PRELIMINARY DEFINITIONS AND NOMENCLATURE

In these Regulations, unless the context otherwise requires

**"Programme"** means Post Graduate Degree Programme (M.Tech. / MCA / M.Sc. / M.Com.)

**"Course"** means a theory / practical / laboratory integrated theory / mini project / seminar / internship / Project and any other subject that is normally studied in a semester like Advanced Concrete Technology, Electro Optic Systems, Financial Reporting and Accounting, Analytical Chemistry, etc.,

**"Institution"** means B.S. Abdur Rahman Crescent Institute of Science & Technology.

**"Academic Council"** means the Academic Council, which is the apex body on all academic matters of B.S. Abdur Rahman Crescent Institute of Science & Technology.

**"Dean (Academic Affairs)"** means Dean (Academic Affairs) of B.S. Abdur Rahman Crescent Institute of Science & Technology who administers the academic matters.

**"Dean (Student Affairs)"** means Dean (Student Affairs) of B.S. Abdur Rahman Crescent Institute of Science & Technology, who looks after the welfare and discipline of the students.

**"Controller of Examinations"** means the Controller of Examinations of B.S. Abdur Rahman Crescent Institute of Science & Technology who is responsible for the conduct of examinations and declaration of results.

## 2.0 PROGRAMMES OFFERED AND ADMISSION REQUIREMENTS

### 2.1 Programmes Offered

The various programmes and their mode of study are as follows:

| Degree | Mode of Study |
|---|---|
| M.Tech. | Full Time |
| MCA | |
| M.Sc. | |
| M.Com. | |

**2.2 ADMISSION REQUIREMENTS**

**2.2.1** Students for admission to the first semester of the Master's Degree Programme shall be required to have passed the appropriate degree examination of this Institution as specified in the clause 3.2 [Eligible entry qualifications for admission to P.G. programmes] or any other degree examination of any University or authority accepted by this Institution as equivalent thereto.

**2.2.2** Eligibility conditions for admission such as class obtained, number of attempts in the qualifying examination and physical fitness will be as prescribed by the Institution from time to time.

**3.0 DURATION, ELIGIBILITY AND STRUCTURE OF THE PROGRAMME**

**3.1**. The minimum and maximum period for completion of the Programmes are given below:

| Programme | Min. No. of Semesters | Max. No. of Semesters |
|---|---|---|
| M.Tech. | 4 | 8 |
| MCA (3 years) | 6 | 12 |
| MCA (Lateral Entry) | 4 | 8 |
| MCA (2 years) | 4 | 8 |
| M.Sc. | 4 | 8 |
| M.Com. | 4 | 8 |

**3.1.1** Each academic semester shall normally comprise of 90 working days. Semester End Examinations shall follow within 10 days of the last Instructional day.

**3.1.2** Medium of instruction, examinations and project report shall be in English.

**3.2 ELIGIBLE ENTRY QUALIFICATIONS FOR ADMISSION TO PROGRAMMES**

| Sl. No. | Name of the Department | Programmes offered | Qualifications for admission |
|---|---|---|---|
| 1. | Aeronautical Engineering | M. Tech. (Avionics) | B.E. / B. Tech. (Aeronautical Engineering) |
| 2. | Civil Engineering | M. Tech. (Structural Engineering) | B.E. / B. Tech. (Civil Engineering) / (Structural Engineering) |
| | | M. Tech. (Construction Engineering and Project Management) | B.E. / B. Tech. (Civil Engineering) / (Structural Engineering) / B. Arch. |
| 3. | Mechanical Engineering | M.Tech. (Manufacturing Engineering) | B.E. / B.Tech. (Mechanical / Automobile / Manufacturing / Production / Industrial / Mechatronics / Metallurgy / Aerospace /Aeronautical / Material Science / Marine Engineering) |
| | | M.Tech. (CAD/CAM) | |
| 4. | Electrical and Electronics Engineering | M.Tech. (Power Systems Engg.) | B.E. / B. Tech. (EEE/ECE/E&I/I&C / Electronics / Instrumentation) |
| | | M.Tech. (Power Electronics and Drives) | |
| 5. | Electronics and Communication Engineering | M.Tech. (Communication Systems) | B.E. / B. Tech. (EEE/ ECE / E&I / CSE IT / I&C / Electronics / Instrumentation) |
| | | M.Tech. (VLSI and Embedded Systems) | B.E. / B. Tech. (ECE / E&I / I&C / EEE / CSE / IT) |
| 6. | Electronics and Instrumentation Engineering | M.Tech. (Electronics and Instrumentation | B.E. / B. Tech. (EIE/ICE/Electronics/ECE/EEE) |

| | | | |
|---|---|---|---|
| | | Engineering) | |
| 7. | Computer Science and Engineering | M.Tech. (Computer Science and Engineering) | B.E. / B. Tech. (CSE/IT/ECE/EEE/EIE/ICE/ Electronics / MCA) |
| | | M.Tech. (Artificial Intelligence and Data Science) | B.E. / B. Tech. (CSE/IT/ECE/EEE/EIE/ICE/ Electronics / MCA) |
| | | M.Tech. (Data Science) | B.E. / B. Tech. (CSE/IT/ECE/EEE/EIE/ICE/ Electronics / MCA) |
| 8. | Information Technology | M.Tech. (Information Technology) | B.E. / B. Tech. (IT/CSE/ECE/EEE/EIE/ICE/ Electronics / MCA) |
| 9. | Computer Applications | MCA (3 years) | Bachelor Degree in any discipline with Mathematics as one of the subjects (or) Mathematics at +2 level |
| | | MCA – (Lateral Entry) | B.Sc. Computer Science / B.Sc. Information Technology / BCA |
| | | MCA (2 years) | Bachelor Degree in any discipline with Mathematics as one of the subjects (or) Mathematics at +2 level or B.Sc. Computer Science / B.Sc. Information Technology / BCA |
| 10. | Mathematics | M.Sc. (Actuarial Science) | Any Degree with Mathematics / Statistics as one of the subjects of study |
| 11. | Physics | M.Sc.(Physics) | B.Sc. (Physics / Applied Science / Electronics / Electronics Science / Electronics & Instrumentation) |

| | | | |
|---|---|---|---|
| 12. | Chemistry | M.Sc.(Chemistry) | B.Sc. (Chemistry / Applied Science) |
| 13. | Life Sciences | M.Sc. Molecular Biology & Biochemistry | B.Sc. in any branch of Life Sciences |
| | | M.Sc. Biotechnology | B.Sc. in any branch of Life Sciences |
| | | M.Sc. Microbiology | B.Sc. in any branch of Life Sciences |
| | | M.Tech. Biotechnology | B.Tech. (Biotechnology / Chemical Engineering) / M.Sc. in any branch of Life Sciences |
| | | M.Tech. Food Biotechnology | B.Tech. (Biotechnology / Chemical Engineering) / M.Sc. in any branch of Life Sciences |
| 14. | Commerce | M.Com | Candidates who have passed B.Com/BBA degree (General or any Specialization) of this Institution or authority accepted by this Institution as equivalent thereto. |

### 3.3. STRUCTURE OF THE PROGRAMME

**3.3.1** The PG programmes consist of the following components as prescribed in the respective curriculum

i. Core courses
ii. Elective courses
iii. Laboratory oriented core courses
iv. Project work / thesis / dissertation
v. Laboratory Courses
vi. Seminars
vii. Mini Project
viii. Industrial Internship
ix. Value Added Courses
x. MOOC Courses ( NPTEL, SWAYAM, etc.,)

**3.3.2** The curriculum and syllabi of all programmes shall be approved by the Academic Council of this Institution.

**3.3.3** For the award of the degree, the student has to earn a minimum total credits specified in the curriculum of the respective specialization of the programme.

**3.3.4** The curriculum of programmes shall be so designed that the minimum prescribed credits required for the award of the degree shall be within the limits specified below:

| Programme | Range of credits |
|---|---|
| M.Tech. | 74 - 80 |
| MCA (3 years) | 118 - 126 |
| MCA (Lateral Entry) | 80 - 85 |
| MCA (2 years) | 85 - 90 |
| M.Sc. | 77- 82 |
| M.Com. | 88 |

**3.3.5** Credits will be assigned to the courses for all programmes as given below:

- ❖ One credit for one lecture period per week or 15 periods of lecture per semester
- ❖ One credit for one tutorial period per week or 15 periods per semester
- ❖ One credit each for seminar/practical session/project of two or three periods per week or 30 periods per semester
- ❖ One credit for four weeks of industrial internship or 160 hours per semester.

**3.3.6** The number of credits the student shall enroll in a non-project semester and project semester is as specified below to facilitate implementation of Choice Based Credit System.

| Programme | Non-project semester | Project semester |
|---|---|---|
| M.Tech. | 9 to 28 | 18 to 26 |
| MCA | 12 to 33 | 12 to 26 |
| M.Sc. | 9 to 32 | 10 to 26 |

**3.3.7** The student may choose a course prescribed in the curriculum

from any department offering that course without affecting regular class schedule. The attendance will be maintained course wise only.

**3.3.8** The students shall choose the electives from the curriculum with the approval of the Head of the Department / Dean of School.

**3.3.9** Apart from the various elective courses listed in the curriculum for each specialization of programme, the student can choose a maximum of two electives from any other similar programmes across departments, during the entire period of study, with the approval of the Head of the department offering the course and parent department.

**3.4. ONLINE COURSES**

**3.4.1** Students are permitted to undergo department approved online courses under SWAYAM up to 20% of credits of courses in a semester excluding project semester with the recommendation of the Head of the Department / Dean of School and with the prior approval of Dean Academic Affairs during his/ her period of study. The credits earned through online courses ratified by the respective Board of Studies shall be transferred following the due approval procedures. The online courses can be considered in lieu of core courses and elective courses.

**3.4.2** Students shall undergo project related online course on their own with the mentoring of the faculty member.

**3.5 PROJECT WORK / DISSERTATION**

**3.5.1** Project work / Dissertation shall be carried out by the student under the supervision of a Faculty member in the department with similar specialization.

**3.5.2** A student may however, in certain cases, be permitted to work for the project in an Industry / Research Organization, with the approval of the Head of the Department/ Dean of School. In such cases, the project work shall be jointly supervised by a faculty of the Department and an Engineer / Scientist from the organization and the student shall be instructed to meet the

faculty periodically and to attend the review meetings for evaluating the progress.

**3.5.3** The timeline for submission of final project report / dissertation is within 30 calendar days from the last Instructional day of the semester in which Project / Dissertation is done.

**3.5.4** If a student does not comply with the submission of project report / dissertation on or before the specified timeline he / she is deemed to have not completed the project work / dissertation and shall re-register in the subsequent semester.

## 4.0 CLASS ADVISOR AND FACULTY ADVISOR

### 4.1 CLASS ADVISOR

A faculty member shall be nominated by the HOD / Dean of School as Class Advisor for the whole class. He/she is responsible for maintaining the academic, curricular and co-curricular records of all students throughout their period of study.

### 4.2 FACULTY ADVISOR

To help the students in planning their courses of study and for general counseling on the academic programme, the Head of the Department / Dean of School of the students shall attach a certain number of students to a faculty member of the department who shall function as Faculty Advisor for the students throughout their period of study. Such Faculty Advisor shall offer advice to the students on academic and personal matters, and guide the students in taking up courses for registration and enrolment in every semester.

## 5.0 CLASS COMMITTEE

**5.1** A class committee comprising faculty members handling the classes, student representatives and a senior faculty member not handling the courses as chairman will be constituted in every semester:

**5.2** The composition of the class committee will be as follows:

i) One senior faculty member preferably not handling courses for the concerned semester, appointed as chairman by the Head of the Department

ii) Faculty members of all courses of the semester

iii) All the students of the class

iv) Faculty advisor and class advisor

v) Head of the Department – Ex officio member

**5.3** The class committee shall meet at least three times during the semester. The first meeting shall be held within two weeks from the date of commencement of classes, in which the nature of continuous assessment for various courses and the weightages for each component of assessment shall be decided for the first and second assessment. The second meeting shall be held within a week after the date of first assessment report, to review the students' performance and for follow up action.

**5.4** During these two meetings the student members, shall meaningfully interact and express opinions and suggestions to improve the effectiveness of the teaching-learning process, curriculum and syllabus.

**5.5** The third meeting of the class committee, excluding the student members, shall meet within 5 days from the last day of the semester end examination to analyze the performance of the students in all the components of assessments and decide their grades in each course. The grades for a common course shall be decided by the concerned course committee and shall be presented to the class committee(s) by the concerned course coordinator.

## 6.0 COURSE COMMITTEE

**6.1** Each common theory / laboratory course offered to more than one group of students shall have a “Course Committee” comprising all the teachers handling the common course with one of them nominated as course coordinator. The nomination of the course coordinator shall be made by the Head of the Department / Dean (Academic Affairs) depending upon whether all the teachers handling the common course belong to a single department or from several departments. The Course Committee shall meet as often as possible to prepare a common

question paper, scheme of evaluation and ensure uniform evaluation of the assessment tests and semester end examination.

## 7.0 REGISTRATION AND ENROLLMENT

**7.1** The students of first semester shall register and enroll at the time of admission by paying the prescribed fees.

**7.2** For the subsequent semesters registration for the courses shall be done by the student one week before the last working day of the previous semester.

**7.3** A student can withdraw from an enrolled course at any time before the first assessment test for genuine reasons, with the approval of the Dean (Academic Affairs), on the recommendation of the Head of the Department of the student.

**7.4** A student can change an enrolled course within 10 working days from the commencement of the course, with the approval of the Dean (Academic Affairs), on the recommendation of the Head of the Department of the student.

## 8.0 TEMPORARY BREAK OF STUDY FROM THE PROGRAMME

**8.1** A student may be permitted by the Dean (Academic Affairs) to avail temporary break of study from the programme up to a maximum of two semesters for reasons of ill health or other valid grounds. A student can avail the break of study before the start of first assessment test of the ongoing semester. However the total duration for completion of the programme shall not exceed the prescribed maximum number of semesters (vide clause 3.1). If any student is debarred for want of attendance or suspended due to any act of indiscipline, it will not be considered as break of study. A student who has availed break of study has to rejoin in the same semester only in the subsequent year. The student availing break of study is permitted to write arrear examinations by paying the prescribed fees.

## 9.0 MINIMUM REQUIREMENTS TO REGISTER FOR PROJECT / DISSERTATION

**9.1** A student is permitted to register for project semester, if he/she

has earned the minimum number of credits specified below:

| Programme | Minimum no. of credits to be earned to enroll for project semester |
|---|---|
| M.Tech. | 18 |
| MCA (3 years) | 45 |
| MCA (Lateral Entry) | 22 |
| MCA (2 years) | 22 |
| M.Sc. | 18 |
| M.Com | NA |

**9.2** If the student has not earned minimum number of credits specified, he/she has to earn the required credits, at least to the extent of minimum credits specified in clause 9.1 and then register for the project semester.

**10.0 ATTENDANCE**

**10.1** A student shall earn 100% attendance in the contact periods of every course, subject to a maximum relaxation of 25% (for genuine reasons such as medical grounds, representing for the institution in approved events, etc.) to become eligible to appear for the semester end examination in that course, failing which the student shall be awarded "I" grade in that course. The courses in which the student is awarded "I" grade, shall register and redo the course when it is offered next.

**10.2** The faculty member of each course shall cumulate the attendance details for the semester and furnish the names of the students who have not earned the required attendance in that course to the Class Advisor. The Class Advisor will consolidate and furnish the list of students who have earned less that 75% attendance, in various courses, to the Dean (Academic Affairs) through the Head of the Department / Dean of School. Thereupon, the Dean (Academic Affairs) shall announce the names of such students prevented from writing the semester

end examination in each course.

**10.3** A student who has obtained 'I' grade in all the courses in a semester is not permitted to move to next higher semester. Such student shall redo all the courses of the semester in the subsequent academic year. However he / she is permitted to redo the courses awarded with 'I' grade / arrear in previous semesters. They shall also be permitted to write arrear examinations by paying the prescribed fee.

**10.4** A student shall register to redo a core course wherein "I" or "W" grade is awarded. If the student is awarded, "I" or "W" grade in an elective course either the same elective course may be repeated or a new elective course may be chosen with the approval of Head of the Department / Dean of School.

**11.0 REDO COURSES**

**11.1** A student can register for a maximum of two redo courses per semester in the evening after regular working hours, if such courses are offered by the concerned department. Students may also opt to redo the courses offered during regular semesters, without affecting the regular academic schedule and not exceeding prescribed maximum credits.

**11.2** The Head of the Department with the approval of Dean (Academic Affairs) may arrange for the conduct of a few courses in the evening after regular working hours, depending on the availability of faculty members and subject to a specified minimum number of students registering for each of such courses.

**11.3** The number of contact hours and the assessment procedure for any redo course will be the same as those during regular semesters except that there is no provision for any substitute examination and withdrawal from an evening redo course.

**12.0 ASSESSMENTS AND EXAMINATIONS**

**12.1** Every theory course shall have a total of three assessments during a semester as given below:

| Assessments | Weightage of Marks |
|---|---|
| Continuous Assessment 1 | 25% |
| Continuous Assessment 2 | 25% |
| Semester End Examination | 50% |

**12.2** Appearing for semester end theory examination for each course is mandatory and a student should secure a minimum of 40% marks in each course in semester end examination for the successful completion of the course.

Every practical course shall have 75% weightage for continuous assessments and 25% for semester end examination. However a student should have secured a minimum of 50% marks in the semester end practical examination for the award of pass grade.

**12.3** For laboratory integrated theory courses, the theory and practical components shall be assessed separately for 100 marks each and consolidated by assigning a weightage of 75% for theory component and 25% for practical component. Grading shall be done for this consolidated mark. Assessment of theory component shall have a total of three assessments with two continuous assessments having 25% weightage each and semester end examination having 50% weightage. The student shall secure a separate minimum of 40% in the semester end theory examination for the award of pass grade. The evaluation of practical component shall be through continuous assessment.

**12.4** The components of continuous assessment for theory/practical/laboratory integrated theory courses shall be finalized in the first class committee meeting.

**12.5** In the case of Industrial training, the student shall submit a report, which shall be evaluated along with an oral examination by a committee of faculty members constituted by the Head of the Department. The student shall also submit an internship completion certificate issued by the industry / research organisation. The weightage for Industry internship report shall be 60% and 40% for viva voce examination.

**12.6** In the case of project work, a committee of faculty members constituted by the Head of the Department will carry out three periodic reviews. Based on the project report submitted by the student, an oral examination (viva voce) shall be conducted as semester end examination by an external examiner approved by Controller of Examinations. The weightage for periodic reviews shall be 50%. Of the remaining 50%, 20% shall be for the project report and 30% for the Viva Voce examination.

**12.7** For the first attempt of the arrear theory examination, the internal assessment marks scored for a course during first appearance shall be considered for grading along with the marks scored in the semester end arrear examination. From the subsequent appearance onwards, full weightage shall be assigned to the marks scored in the semester end examination to award grades and the internal assessment marks secured during the course of study shall not be considered.

In case of laboratory integrated theory courses, after one regular and one arrear appearance, the internal mark of theory component is invalid and full weightage shall be assigned to the marks scored in the semester end arrear examination for theory component. There shall be no arrear or improvement examination for lab component.

**13.0 SUBSTITUTE EXAMINATIONS**

**13.1** A student who is absent, for genuine reasons, may be permitted to write a substitute examination for any one of the two continuous assessment tests of a course by paying the prescribed substitute examination fee. However, permission to take up a substitute examination will be given under exceptional circumstances, such as accidents, admission to a hospital due to illness, etc. by a committee constituted by the Head of the Department / Dean of School for that purpose. However there is no substitute examination for semester end examination.

**13.2** A student shall apply for substitute exam in the prescribed form to the Head of the Department / Dean of School within a week

from the date of assessment test. However the substitute examination will be conducted only after the last working day of the semester and before the semester end examination.

**14.0 SUPPLEMENTARY EXAMINATION**

**14.1** Final Year students can apply for supplementary examination for a maximum of three courses thus providing an opportunity to complete their degree programme. Likewise students with less credit can also apply for supplementary examination for a maximum of three courses to enable them to earn minimum credits to move to higher semester. The students can apply for supplementary examination within three weeks of the declaration of results in both odd and even semester.

**15. PASSING, DECLARATION OF RESULTS AND GRADE SHEET**

**15.1** All assessments of a course shall be made on absolute marks basis. However, the Class Committee without the student members shall meet within 5 days after the semester end examination and analyze the performance of students in all assessments of a course and award letter grades. The letter grades and the corresponding grade points are as follows:

| Letter Grade | Grade Points |
|---|---|
| S | 10 |
| A | 9 |
| B | 8 |
| C | 7 |
| D | 6 |
| E | 5 |
| U | 0 |
| W | 0 |
| I | 0 |
| AB | 0 |

**"W"** denotes withdrawal from the course.

**“I”** denotes inadequate attendance and hence prevented from

appearing for semester end examination

**"U"** denotes unsuccessful performance in the course.

**"AB"** denotes absence for the semester end examination.

**15.2** A student who earns a minimum of five grade points ('E' grade) in a course is declared to have successfully completed the course. Such a course cannot be repeated by the student for improvement of grade.

**15.3** The results, after awarding of grades, shall be signed by the Chairman of the Class Committee and Head of the Department / Dean of School and it shall be declared by the Controller of Examinations.

**15.4** Within one week from the date of declaration of result, a student can apply for revaluation of his / her semester end theory examination answer scripts of one or more courses, on payment of prescribed fee to the Controller of Examinations. Subsequently the Head of the Department/ Dean of School offered the course shall constitute a revaluation committee consisting of Chairman of the Class Committee as convener, the faculty member of the course and a senior faculty member knowledgeable in that course as members. The committee shall meet within a week to re-evaluate the answer scripts and submit its report to the Controller of Examinations for consideration and decision.

**15.5** After results are declared, grade sheets shall be issued to each student, which contains the following details: a) list of courses enrolled during the semester including redo courses / arrear courses, if any; b) grades scored; c) Grade Point Average (GPA) for the semester and d) Cumulative Grade Point Average (CGPA) of all courses enrolled from first semester onwards.

GPA is the ratio of the sum of the products of the number of credits of courses registered and the grade points corresponding to the grades scored in those courses, taken for all the courses, to the sum of the number of credits of all the courses in the semester.

If $C_i$, is the number of credits assigned for the $i^{th}$ course and $GP_i$ is the Grade Point in the $i^{th}$ course

$$GPA = \frac{\sum_{i=1}^{n}(C_i)(GPi)}{\sum_{i=1}^{n} C_i}$$

Where n = number of courses

The Cumulative Grade Point Average (CGPA) is calculated in a similar manner, considering all the courses enrolled from first semester.

**“I” and "W"** grades are excluded for calculating GPA.

**"U", “I”, "AB"** and **"W"** grades are excluded for calculating CGPA.

The formula for the conversion of CGPA to equivalent percentage of marks is as follows:

Percentage Equivalent of Marks = CGPA X 10

**15.6** After successful completion of the programme, the Degree shall be awarded upon fulfillment of curriculum requirements and classification based on CGPA as follows:

| Classification | CGPA |
|---|---|
| First Class with Distinction | 8.50 and above and passing all the courses in first appearance and completing the programme within the minimum prescribed period. |
| First Class | 6.50 and above and completing the programme within a minimum prescribed period plus two semesters. |
| Second Class | Others |

However, to be eligible for First Class with Distinction, a student should not have obtained ‘U’ or ‘I’ grade in any course during his/her period of study and should have completed the P.G. programme within a minimum period (except break of study). To be eligible for First Class, a student should have passed the examination in all the courses within the specified minimum number of semesters reckoned from his/her commencement of

study plus two semesters. For this purpose, the authorized break of study is not considered. The students who do not satisfy the above two conditions shall be classified as second class. For the purpose of classification, the CGPA shall be rounded to two decimal places. For the purpose of comparison of performance of students and ranking, CGPA will be considered up to three decimal places.

**16.0 DISCIPLINE**

**16.1** Every student is expected to observe disciplined and decorous behaviour both inside and outside the campus and not to indulge in any activity which tends to affect the reputation of the Institution.

**16.2** Any act of indiscipline of a student, reported to the Dean (Student Affairs), through the HOD / Dean shall be referred to a Discipline and Welfare Committee constituted by the Registrar for taking appropriate action.

**17.0 ELIGIBILITY FOR THE AWARD OF THE MASTERS DEGREE**

**17.1** A student shall be declared to be eligible for the award of the Masters Degree, if he/she has:

i. Successfully acquired the required credits as specified in the curriculum corresponding to his/her programme within the stipulated time.
ii. No disciplinary action is pending against him/her.
iii. Enrolled and completed at least one value added course.
iv. Enrollment in at least one MOOC / SWAYAM course (non-credit) before the final semester.

**17.2** The award of the degree must have been approved by the Institute.

**18.0 POWER TO MODIFY**

Not withstanding all that have been stated above, the Academic Council has the right to modify any of the above regulations from time to time.

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# B.S. ABDUR RAHMAN CRESCENT INSTITUTE OF SCIENCE AND TECHNOLOGY

## M.TECH. DATA SCIENCE

## CURRICULUM & SYLLABUS, REGULATIONS 2021

### SEMESTER I

| Sl. No. | Course Group | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|---|
| 1. | BS | MAD 6189 | Statistical Methods for Data Science | 3 | 1 | 0 | 4 |
| 2. | EC | CSD 6141 | Data Structures with Algorithms | 3 | 0 | 0 | 3 |
| 3. | EC | CSD 6142 | Big Data Analytics | 3 | 0 | 2 | 4 |
| 4. | EC | CSD 6143 | Machine learning | 3 | 0 | 0 | 3 |
| 5. | EC | CSD 6144 | Data Science Foundations using R. | 3 | 0 | 2 | 4 |
| 6. | PE | | Professional Elective I | 3 | 0 | 0 | 3 |
| | | | **Credits** | | | | **21** |

### SEMESTER II

| Sl. No. | Course Group | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|---|
| 1. | BS | GED 6201 | Research Methodology for Engineers | 3 | 1 | 0 | 4 |
| 2. | EC | CSD 6241 | Data Visualization Techniques | 2 | 0 | 1 | 3 |
| 3. | EC | CSD 6222 | Deep Learning | 3 | 0 | 2 | 4 |
| 4. | PE | | Professional Electives II | | | | 9 |
| 5. | | | Value Added Course | | | | -- |
| | | | **Credits** | | | | **20** |

**SEMESTER III**

| Sl. No. | Course Group | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|---|
| 1. | EC | CSD 7141 | Internship * | 0 | 0 | 2 | 1 |
| 2. | PE | | Professional Electives- III | | | | 6 |
| 3. | GE | | General Elective | 3 | 0 | 0 | 3 |
| 4. | EC | CSD 7142 | Project – Phase I # | 0 | 0 | 12 | 6 |
| 5. | | | MOOC Course | | | | -- |
| | | | **Credits** | | | | **16** |

**SEMESTER IV**

| Sl. No. | Course Group | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|---|
| 1. | EC | CSD 7142 | Project – Phase II | 0 | 0 | 36 | 18 |
| 2. | | | | | | 6 +18= | 24 |
| | | | **Credits** | | | | **24** |

**Overall Total Credits – 75**

* Industrial training will be undertaken during first year summer vacation for 30 days. The credit will be awarded in the 3rd Semester.

# Credits for Project Work Phase I to be accounted along with Project Work Phase II in IV Semester

## LIST OF PROFESSIONAL ELECTIVE COURSES

### Electives – Semester I

| Sl. No. | Course Group | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|---|
| 1. | BS | MADY 02 | Time Series Analysis | 3 | 0 | 0 | 3 |
| 2. | PE | CSDY 351 | Business Intelligence | 3 | 0 | 0 | 3 |
| 3. | PE | CSDY 352 | Artificial Intelligence | 3 | 0 | 0 | 3 |
| 4. | PE | CSDY 301 | SQL for Data Science | 3 | 0 | 0 | 3 |
| 5. | PE | CSDY 302 | Cloud Computing and Technology | 3 | 0 | 0 | 3 |

### Electives –Semester II

| Sl. No. | Course Group | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|---|
| 1. | BS | CSDY 353 | Optimization methods for Analytics | 3 | 0 | 0 | 3 |
| 2. | PE | CSDY 354 | Knowledge Representation and Reasoning | 3 | 0 | 0 | 3 |
| 3. | PE | CSDY 355 | Data Science with Bio Informatics | 3 | 0 | 0 | 3 |
| 4. | PE | CSDY 356 | Neural Networks | 3 | 0 | 0 | 3 |
| 5. | PE | CSDY 357 | Predictive Analytics | 3 | 0 | 0 | 3 |
| 6. | PE | CSDY 358 | Introduction to R Programming | 3 | 0 | 0 | 3 |
| 7. | PE | CSDY 359 | Web Analytics | 3 | 0 | 0 | 3 |
| 8. | PE | CSDY 360 | Real Time Analytics | 3 | 0 | 0 | 3 |
| 9. | PE | CSDY 361 | Data Engineering | 3 | 0 | 0 | 3 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 10. | PE | CSDY 305 | Intelligent Information Retrieval | 3 | 0 | 0 | 3 |
| 11. | PE | CSDY 306 | Data Analytics | 3 | 0 | 0 | 3 |
| 12. | PE | CSDY 307 | Soft Computing Techniques | 3 | 0 | 0 | 3 |

## Electives –Semester III

| Sl. No. | Course Group | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|---|
| 1. | PE | CSDY 362 | Ethics for Data Science | 3 | 0 | 0 | 3 |
| 2. | PE | CSDY 363 | Social Network Analysis and Mining | 3 | 0 | 0 | 3 |
| 3. | PE | CSDY 364 | Deep Learning for Computer Vision | 3 | 0 | 0 | 3 |
| 4. | PE | CSDY 365 | Multimedia Systems | 3 | 0 | 0 | 3 |
| 5. | PE | CSDY 366 | Customer Relational Management | 3 | 0 | 0 | 3 |
| 6. | PE | CSDY 367 | Web database and information system | 3 | 0 | 0 | 3 |
| 7. | PE | CSDY 312 | Pattern Recognition for Machine Learning | 3 | 0 | 0 | 3 |
| 8. | PE | CSDY 313 | Advanced Machine Learning | 3 | 0 | 0 | 3 |

## GENERAL ELECTIVE

| Sl. No. | Course Code | Course Title | L | T | P | C |
|---|---|---|---|---|---|---|
| 1. | GEDY 101 | Project Management | 3 | 0 | 0 | 3 |
| 2. | GEDY 102 | Society, Technology and Sustainability | 3 | 0 | 0 | 3 |
| 3. | GEDY 103 | Artificial Intelligence | 3 | 0 | 0 | 3 |
| 4. | GEDY 104 | Green Computing | 3 | 0 | 0 | 3 |
| 5. | GEDY 105 | Gaming Design | 3 | 0 | 0 | 3 |
| 6. | GEDY 106 | Social Computing | 3 | 0 | 0 | 3 |
| 7. | GEDY 107 | Soft Computing | 3 | 0 | 0 | 3 |
| 8. | GEDY 108 | Embedded System Programming | 3 | 0 | 0 | 3 |
| 9. | GEDY 109 | Principles of Sustainable Development | 3 | 0 | 0 | 3 |
| 10. | GEDY 110 | Quantitative Techniques in Management | 3 | 0 | 0 | 3 |
| 11. | GEDY 111 | Programming using MATLAB and SIMULINK | 1 | 0 | 2 | 2 |
| 12. | GEDY 112 | JAVA Programming | 3 | 0 | 0 | 3 |
| 13. | GEDY 113 | PYTHON Programming | 3 | 0 | 0 | 3 |
| 14. | GEDY 114 | Intellectual Property Rights | 1 | 0 | 0 | 1 |
| 15. | GEDY 115 | Research and Publication Ethics | 2 | 0 | 0 | 2 |
| 16. | GEDY 116 | IPR and Entrepreneurship | 3 | 0 | 0 | 3 |
| 17. | GEDY 117 | Nanotechnology in Food Applications | 3 | 0 | 0 | 3 |

## SEMESTER I

| MAD 6189 | STATISTICAL METHODS FOR DATA SCIENCE | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**SDG: 9**

**COURSE OBJECTIVES:**

**COB1:** To introduce regression techniques to evaluate the relationship between dependent and independent variables

**COB2:** To learn how to draw repeated samples from the original data samples

**COB3:** To evaluate the estimation of coefficients by linear combinations

**COB4:** To model data as a function which is a nonlinear combination of the model parameters

**COB5:** To apply tree based methods that can be used for both regression and classification of data

**MODULE I** **REGRESSION** **9+3**

Simple linear Regression-Multiple linear regression- Logistic regression-Discriminant Analysis.

**MODULE II** **RESAMPLING METHODS** **9+3**

Bootstrapping- Cross validation - Subset selection – Forward, Backward, Stepwise and Best.

**MODULE III** **DIMENSION REDUCTION** **9+3**

Ridge Regression, Principal Components Regression – Partial Least squares.

**MODULE IV** **NON LINEAR METHODS** **9+3**

Step function – Piecewise function – Splines – Generalized Additive Model.

**MODULE V** **TREE BASED METHODS** **9+3**

Bagging – Boosting - Random Forests - Support Vector Machines – Unsupervised learning – Principal component Analysis- k- means clustering – Hierarcical clustering.

**L – 45; T-15; Total Hours – 60**

**TEXT BOOKS:**

1. James D. Miller, “Statistics for data science” , Packt Publ. Ltd. Mumbaie . 2017
2. Devore. J.L., "Probability and Statistics for Engineering and the Sciences”, Cengage Learning, New Delhi, 8th Edition, 2012.

**REFERENCES:**

1. Walpole R.E, K.E.Ye and R.H. Myers, “Probability and Statistics for Engineers and Scientists”, 9th Edition ,Pearson 2016
2. Peter Bruce, “ Practical Statistics for Data Scientists”, 2017
3. Vincent Granville, “Statistics- Toolbox, New Foundations

**COURSE OUTCOMES:**

At the end of the course students will be able to

**CO1:** Classify a recorded phenome based on a log - periodogram

**CO2:** Customize an email spam detection system

**CO3:** Identify the numbers in a handwritten zipcode

**CO4:** Classify a tissue sample into one of several cancer classes

**CO5:** Establish the relationship between salary and demographic variables in population survey area

| **Board of Studies (BoS):** | **Academic Council:** |
|---|---|
| 12th BOS of Mathematics & AS held on 23.06.2021 | 17th AC held on 15.07.2021 |

SDG 9 : Sustainable Industry, innovation and Infrastructure

Learning of various techniques in Graph theory and Combinatorics will lead to knowledge required for applying in Computer Science projects.

| CSD 6141 | DATA STRUCTURES WITH ALGORITHMS | L | T | P | C |
|---|---|---|---|---|---|
| SDG: 4 | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

**COB1:** To discuss various algorithm design techniques for developing algorithms.

**COB2:** To study the basic techniques for designing algorithms, including the techniques of recursion, divide-and-conquer, and greedy.

**COB3:** To provide the basic knowledge of computational complexity, approximation and randomized algorithms.

**COB4:** To Learn the advanced techniques for designing algorithms, including dynamic programming, network flow and problem reduction

**COB5:** To determine the time and space complexity of simple algorithms and recursively defined algorithms.

**MODULE I INTRODUCTION 09**

Introduction and Motivation-Lower Bound-Asymptotic Notations-Mathematical Induction-Mathematical models-Formulating the Equations-Solving the equationsHomogeneous Linear Recurrence with Constant Coefficients-Non-homogeneous Equations-Transformations.

**MODULE II HIERARCHICAL DATA STRUCTURES 09**

Binary Search Trees: Basics – Querying a Binary search tree – Insertion and Deletion- Red-Black trees: Properties of Red-Black Trees – Rotations – Insertion – Deletion -B-Trees: Definition of Btrees – Basic operations on B-Trees – Deleting a key from a B-Tree- Fibonacci Heaps: structure – Mergeable-heap operations- Decreasing a key and deleting a node-Bounding the maximum degree.

**MODULE III DIVIDE-AND-CONQUERANDRANDOMIZED ALGORITHMS 09**

The maximum-sub array problem- Strassen's algorithm for matrix multiplication- The substitution method for solving recurrences-The recursion-tree method for solving recurrences-The master method for solving recurrences-Proof of the master theoremThe hiring problem- Indicator random variables-Randomized algorithms-Probabilistic analysis and further uses of indicator random variables.

**MODULE IV ALGORITHM DESIGN TECHNIQUE 09**

Dynamic Programming: Matrix-Chain Multiplication – Elements of Dynamic Programming – Longest Common Subsequence- Greedy Algorithms: An Activity-Selection Problem – Elements of the Greedy Strategy- Huffman Codes.

**MODULE V NP-COMPLETENESS AND APPROXIMATION ALGORITHMS 09**

Polynomial time-Polynomial-time verification-NP-completeness and reducibility-NPcompleteness proofs-NP-complete problems- Approximation Algorithms-The vertexcover problem-The traveling-salesman problem-The set-covering problemRandomization and linear programming-The subset-sum problem.

**L – 45; Total Hours – 45**

**TEXTBOOKS:**

1. Alfred V Aho, John E Hopcrof," The Design and Analysis of Computer Algorithms", Pearon Education, 4th Edition, ISBN: 978813170205,2009.

**REFERENCES:**

1. E.M.David,"Introduction to Data Structures and Algorithms For Dummies", 1st Edition kindle, B08SBXBR2Z, 2021.
2. Robert Sedgewick, Kevin Wayne, "Algorithms", 4th Edition, Addison Wesley, ISBN-13: 978-0321573513, 2011
3. Mark Allen Weiss," Data Structures and Algorithm Analysis in C++", AddisonWesley,3rd edition, ISBN: 978-0132847377,2013.

**COURSE OUTCOMES:**

**CO1:** Enable studens to prove the correctness of algorithms using inductive proofs and invariants.

**CO2:** Analyze randomized algorithms with respect to expected running time, probability of error using tail inequalities

**CO3:** Classify problems into different complexity classes corresponding to both deterministic and randomized algorithms

**CO4:** Implement both a greedy and a divide-and-conquer algorithm to solve problems.

**CO5:** Design the techniques of proof by contradiction, mathematical induction and recurrence relation, and apply them to prove the correctness and to analyze the running time of algorithms.

**Board of Studies (BoS) :**
18th BoS of CSE held on 26.06.2021

**Academic Council:**
17th AC held on 15.07.2021

| | PO1 | PO2 | PO3 | PO4 |
|---|---|---|---|---|
| CO1 | | | L | |
| CO2 | | H | | |
| CO3 | | | | |
| CO4 | | | | M |
| CO5 | | H | | |

SDG 4: Quality Education

Statement: Large amount of education data in the higher education system are gathered daily from various sources and in various formats like the students' interaction with learning management systems, learning activities, courses information, examination results, course work assessments, administration and teaching processes.

| CSD 6142 | BIG DATA ANAYLTICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 2 | 4 |

**SDG: 9**

**COURSE OBJECTIVES:**

**COB1:** To explore the fundamental concepts of big data analytics.

**COB2:** Learn to build and maintain reliable, scalable, distributed systems with Apache Hadoop.

**COB3:** To formulate queries and evaluate using Hive and HBase.

**COB4:** To introduce the tools required to manage and analyze big data like Hadoop, Spark SQL and machine Learning.

**COB5:** To expose higher level APIs and apply machine learning techniques in Big data.

**MODULE I INTRODUCTION TO BIG DATA 7**

Introduction - Analytics, Big Data, Characteristics of Big Data, Domain Specific examples of Big Data, Analytics flow for Big Data, Big Data Stack.

**MODULE II HADOOP ARCHITECTURE & ECOSYSTEM 9**

Hadoop eco system – Big data workflows – Hadoop architecture – Hadoop cluster – HDFS – Working with distributed file System – MapReduce – Hadoop streaming.

**MODULE III HIVE AND HIVEQL, HBASE 10**

Data Mining basics - Structured data queries with Hive – Hive Command line Interface – Hive query language – data analysis with Hive – HBase. Importing relational data with Sqoop – MySQL to HDFS – MySQL to Hive – MySQL to HBase, Pig.

**MODULE IV SPARK PROGRAMMING 9**

Spark Basics – Spark Stack – Resilient Distributed Data Sets – Working with Resilient Distributed Data Sets. Basics of Machine Learning – Supervised and Unsupervised Algorithms – Applications and Examples – Data visualization.

**MODULE V MONGODB 10**

Introduction to MongoDB key features – Core Server tools – MongoDB through the JavaScript's Shell –Creating and Querying through Indexes – Document-Oriented – principles of schema design – Constructing queries on Databases – collections and Documents – MongoDB Query Language

**PRACTICALS**

1. Hadoop Installation.
2. Simple program execution on Hadoop.
3. Python basic programming.
4. MapReduce problem using Python.
5. Database connectivity and query evaluation using HBase and Hive.
6. Mongo DB Query Language
7. Case studies on data analytics.

**L – 45 ; P – 30 ; Total Hours – 75**

**TEXT BOOKS:**

1. Benjamin Bengfort, Jenny Kim, “Data Analytics with Hadoop”, O'Reilly Media, Inc., First edition, ISBN: 1491913703, 2019.
2. Soraya Sedkaoui, “Data Analytics and Big Data”, First Edition, Wiley Publications, 2018. ISBN 978-1-78630-326-4, 2018.
3. Kyle Banker,Piter Bakkum , Shaun Verch, “MongoDB in Action”, Dream Tech Press, 2016

**REFERENCES:**

1. Sridhar Alla “Big data analytics with hadoop3:” Packt Publishing, ISBN: 1788624955, 2019.
2. Arshdeep Bahga & Vijay Madisetti , “Big Data Analytics: A Hands-On Approach” ISBN: 978-1-949978-00-1, 2019.

**COURSE OUTCOMES:**

**CO1:** Differentiate traditional data processing with Big Data Analytics.

**CO2:** Analyze the Hadoop and Map Reduce technologies associated with big data analytics.

**CO3:** Explore on Big Data applications Using Hive, HBase and Pig.

**CO4:** Familiarize with tools and techniques with Apache spark, with Hadoop platform and machine learning.

**CO5:** Be able to design and build MongoDB based Big data Applications and learn MongoDB query language.

**Board of Studies (BoS) :**
18th BoS of CSE held on 26.06.2021

**Academic Council:**
17th AC held on 15.07.2021

| | PO1 | PO2 | PO3 | PO4 |
|---|---|---|---|---|
| **CO1** | | L | | |
| **CO2** | | | | L |
| **CO3** | | | L | M |
| **CO4** | M | | | H |
| **CO5** | H | L | L | M |

SDG 9 : Build resilient Infrastructure, promote inclusive and sustainable industrialization and foster innovation

Statement: Bigdata Analytics can provide critical aid to the existing response techniques and make changes in the decision-making process in sustainable industrialization.

**CSD 6143** **MACHINE LEARNING** **L T P C**

**3 0 0 3**

**SDG: 9**

**COURSE OBJECTIVES:**

**COB1:** To familiarize the students with basic learning algorithms and techniques and their applications.

**COB2:** To provide knowledge on supervised and unsupervised learning.

**COB3:** To explore, design and evaluate various machine learning models.

**COB4:** To apply machine learning to data analytics.

**COB5:** To emphasis on machine learning algorithms and applications.

**MODULE I THE INGREDIENTS OF MACHINE LEARNING 7**

Tasks: the problems that can be solved with machine learning - Looking for structure - Evaluating performance on a task - Models: the output of machine learning - Geometric models - Probabilistic models - Logical models – Grouping and grading - Features: the workhorses of machine learning - Two uses of features - Feature construction and transformation - Interaction between features.

**MODULE II CLASSIFICATION AND REGRESSION 10**

Classification - Scoring and ranking - Class probability estimation - Binary classification and related tasks - Handling more than two classes - Regression - Unsupervised and descriptive learning.

**MODULE III TREE AND RULE MODELS 10**

The hypothesis space - Paths through the hypothesis space - Beyond conjunctive concepts - Learnability - Tree models - Decision trees - Ranking and probability estimation - Sensitivity to skewed class distributions - Tree learning as variance reduction Tree models: Summary and further reading - Rule models – Learning ordered rule lists -Learning unordered rule sets - Descriptive rule learning - First-order rule learning.

**MODULE IV LINEAR AND DISTANCE BASED MODELS 10**

The least-squares – The perceptron - Support vector machines - Obtaining probabilities from linear classifiers - Going beyond linearity with kernel methods - Neighbours and exemplars - Nearest-neighbour classification - Distance-based clustering - Hierarchical clustering – From kernels to

distances.

**MODULE V FEATURES AND ENSEMBLES 8**

Kinds of feature - Feature transformations - Feature construction and selection - Model ensembles - Bagging and random forests - Boosting - Mapping the ensemble landscape – Machine Learning Experiments.

**L – 45 ; Total Hours – 45**

**TEXT BOOKS:**

1. Stephen Marsland, “Machine Learning –An Algorithmic Perspective”, CRC Press, second Edition, ISBN:9781420067194, 1420067192,2015.

**REFERENCES:**

1. Peter Flach, “Machine Learning: The Art and Science of Algorithms that Make Sense of Data”, Cambridge University Press, Eighth Edition, ISBN 978-1-107-09639-4, 2012.
2. Yaser S. Abu-Mostafa, Malik Magdon-Ismail, Hsuan-Tien Lin, “Learning From Data”, AML Book, ISBN-13: 978-1600490064, 2012.
3. Peter Bradley, Ashok Mohanty, “Machine Learning: A Complete Exploration of Highly Advanced Machine Learning Concepts, Best Practices and Techniques”, Independently Published, ISBN 978-1795201728, 2019.

**COURSE OUTCOMES:**

**CO1:** Understand the fundamental issues and challenges of machine learning: data, model selection, model complexity, etc.

**CO2:** Exemplify the strengths and weaknesses of many popular machine learning approaches.

**CO3**: Understand the underlying mathematical relationships within and across Machine Learning algorithms and the paradigms of supervised and un-supervised learning.

**CO4:** Design and implement various machine learning algorithms in a range of real-world applications.

**CO5:** Solve data analytics case studies applying machine learning techniques.

**Board of Studies (BoS) :**
18th BoS of CSE held on 26.06.2021

**Academic Council:**
17th AC held on 15.07.2021

| | PO1 | PO2 | PO3 | PO4 |
|---|---|---|---|---|
| **CO1** | | M | M | |
| **CO2** | | M | M | |
| **CO3** | | | H | H |
| **CO4** | | | M | H |
| **CO5** | H | | | H |

SDG 9 : Build resilient Infrastructure, promote inclusive and sustainable industrialization and foster innovation

Statement: Machine learning has large number of applications such as healthcare, agriculture, security and even in day-to-day life. Machine learning algorithms can be helpful for different engineering disciplines such as mechanical, civil, chemical engineering that are working for sustainable development of the society.

| CSD 6144 | DATA SCIENCE FOUNDATIONS USING R | L | T | P | C |
|---|---|---|---|---|---|
| SDG: | | 3 | 0 | 2 | 4 |

**COURSE OBJECTIVES:**

**COB1:** To learn the basics of Data science.

**COB2:** To understand various the classification techniques

**COB3:** To provide knowledge on different Regression methods

**COB4:** To understand the clustering techniques used in data science

**COB5:** To learn the various data science functionalities in R language

**MODULE I INTRODUCTION 9**

Introduction - Ai, Machine Learning and Data Science, What is Data Science?, Case for Data Science, Data Science Classification, Data Science Algorithms – Data Science Process- Data Preparation, Modeling, Application, Knowledge - Data Exploration- Objectives Of Data Exploration, Datasets, Descriptive Statistics, Data Visualization.

**MODULE II CLASSIFICATION 9**

Classification - Decision Trees, Rule Induction, K-Nearest Neighbors, Naïve Bayesian, Artificial Neural Networks, Support Vector Machines, Ensemble Learners.

**MODULE III REGRESSION METHODS & ASSOCIATION ANALYSIS 9**

Regression Methods - Linear Regression, Logistic Regression, Association Analysis - Mining Association Rules, Apriori Algorithm, Frequent Pattern-Growth Algorithm.

**MODULE IV CLUSTERING 9**

Clustering - Types Of Clustering Techniques - K-Means Clustering, Dbscan Clustering, Self-Organizing Maps, Model Evaluation - Confusion Matrix, Roc And Auc, Lift Curves.

**MODULE V Data Science Using R 9**

Data Visualization with ggplot2 - Introduction, Aesthetic mappings, Common Problems, Facets, Geometric Objects, Statistical Transformation, Position Adjustments, Coordinate Systems. Data Transformation with dplyr – Filter rows with filter(), arrange(), select(), mutate(), summarize(), Grouped mutates. Exploratory Data Analysis – Questions, Variation, Missing Values,

Covariation, patterns and models, ggplot2 calls.

**PRACTICALS**

List of Experiments

1. Write an R script to find basic statistics using summary, str, quartile function on cars datasets.
2. Write an R script to find subset of dataset by using subset (), aggregate () functions on iris dataset
3. a. Write a program for Reading Excel data sheet in R.
   b. Write a program for Reading XML dataset in R.
   c. Write a program for Reading SQL Data in R.
   d. Write a program for Reading NoSQL data in R.
4. Write a R script to find the data distributions using box and scatter plot.
5. Write a R script to find the outliers using plot.
6. Write a R script to plot the histogram, bar chart and pie chart on sample data.
7. Write a R script to find Correlation and Covariance
   a. Find the correlation matrix.
   b. Plot the correlation plot on dataset and visualize giving an overview of relationships among data on iris data.
   c. Analysis of covariance: variance (ANOVA), if data have categorical variables on iris data.
8. Write a Classification process in R.
   a. Install relevant package for classification.
   b. Choose classifier for classification problem.
   c. Evaluate the performance of classifier.
9. Write a Clustering process in R.
   a. Clustering algorithms for unsupervised classification.
   b. Plot the cluster data using R visualizations.

**L - 45; P - 30; Total Hours - 75**

**TEXT BOOKS:**

1. Avrim Blum, John Hopcroft, and Ravindran Kannan, “Foundations of Data Science”, Cambridge University Press, 2020, ISBN:9781108485067, 1108485065
2. Hadley Wickham, Garrett Grolemund , “R for Data Science Import, Tidy, Transform, Visualize, and Model Data”, O'Reilly Media, 2017, ISBN:9781491910368, 1491910364

**REFERENCES:**

1. Nina Zumel, John Mount, “Practical Data Science with R”, Manning Publications, 2019, ISBN:9781617295874, 1617295876.

**COURSE OUTCOMES:**

**CO1:** Explain basics of data science.

**CO2:** Examine the various classification techniques.

**CO3:** Identify various regression models

**CO4:** Use appropriate clustering techniques on data

**CO5:** Implement data science concepts in R.

**Board of Studies (BoS) :**
18th BoS of CSE held on 26.06.2021

**Academic Council:**
17th AC held on 15.07.2021

| | PO1 | PO2 | PO3 | PO4 |
|---|---|---|---|---|
| CO1 | M | L | | |
| CO2 | M | | H | M |
| CO3 | M | L | H | M |
| CO4 | M | | H | M |
| CO5 | M | L | H | H |

SDG 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.

Statement: By learning “Data Science Foundations using R”, the students are able to develop and evaluate ideas for sustainability-driven innovation and entrepreneurship.

| VALUE ADDED COURSE | L | T | P | C |
|---|---|---|---|---|
| | 0 | 0 | 0 | 0 |

**OBJECTIVES:**

- To expose the latest technology / tools used in the industry and enable the students acquire knowledge and skill set in the same.

**GENERAL GUIDELINES:**

- Students should undergo any relevant certification course offered by the institution or other institutions / universities / IIT / IISc etc. for a minimum of 40 hours.
- Selection and completion of value added course by the students shall be endorsed by Head of the Department.

**OUTCOMES:**

- Students should be exposed and gained knowledge in any one latest technology used in the industry

| MOOC COURSE | L | T | P | C |
|---|---|---|---|---|
| | 0 | 0 | 0 | 0 |

**OBJECTIVES:**

- To learn the basics principles and concepts of the topic in which a project work is undertaken by the student.

**GENERAL GUIDELINES:**

- Students shall identify a MOOC course related to his/her project topic in consultation with the project supervisor.
- Student shall register for a MOOC course with minimum two credit offered by any recognized organization during the project phase I.
- Selection and completion of MOOC course by the students shall be endorsed by Head of the Department.

**OUTCOMES:**

Students will be able to

- Familiarize the basic principles and concepts related to the topic of his/her project work.
- Utilize the knowledge gained in the field of study to perform literature review with ease.
- Formulate the experimental / analytical methodology required for the project work

**ELECTIVE - SEMESTER I**

| **MADY 02** | **TIME SERIES ANALYSIS** | **L** | **T** | **P** | **C** |
|---|---|---|---|---|---|
| | | **3** | **0** | **0** | **3** |

**COURSE OBJECTIVES:**

**COB1:** To introduce basic ideas of Time series and linear difference equations needed for parametric modeling.

**COB2:** To introduce ARMA models.

**COB3:** To introduce ARMA (p,q) model and ARIMA models for Non-stationary time series

**COB4:** To apply Fourier series and complex analysis basic in Spectral Analysis.

**COB5:** To estimate the parameters and forecasting with ARMA processes

**MODULE I INTRODUCTION 9**

Stochastic Processes – The Autocovariance and Autocorrelation functions – The Partial Autocorrelation function – White Noise Proceeses – Estimation of the Mean, Autocovariances and Autocorrelations – Moving Average and Autoregressive representations of Time series processes – Linear Difference Equations

**MODULE II STATIONARY PROCESSES 9**

Basic Properties – Linear Processes – Introduction to ARMA Processes – Properties of the sample mean and Autocorrelation function – Forecasting stationary time series

**MODULE III ARMA AND NON STATIONARY TIME SERIES MODELS 9**

ARMA (p,q) Processes – The ACF and PACF of an ARMA (p,q) process – Forecasting ARMA Processes - ARIMA Models for Nonstationary time series – Identification techniques – Unit roots in time series models – Forecasting ARIMA models

**MODULE IV SPECTRAL ANALYSIS 9**

Spectral densities – The Periodogram – Time – invariant Linear Filters – The Spectral Density of an ARMA process.

**MODULE V MODELLING AND FORECASTING WITH ARMA PROCESSES 9**

Preliminary Estimation – Maximum Likelihood Estimation – Diagnostic checking – Forecasting – Order Selection

**L – 45; Total Hours – 45**

**TEXT BOOKS:**

1. Chris Chatfield, “The Analysis of Time Series An Introduction”, Chapman & Hall, 2009.
2. Peter J. Brockwell and Richard A. Davis, "Introduction to time series and forecasting”, Springer, 2nd Edition, 2002.

**REFERENCES:**

1. James D. Hamilton, “Time Series Analysis”, Princeton University press Princeton, New Jersey, 1994.
2. William W. S. Wei, “ Time Series Analysis Univariate and Multivariate Methods ”, Second edition, 2006.
3. Shumway and Stoffer, “Time Series Analysis and its Applications with R examples”, Third edition, 2016.

**COURSE OUTCOMES:** At the end of the course students will be able to

**CO1:** solve the parametric modeling

**CO2:** apply ARMA models

**CO3:** apply ARMA (p,q) and ARIMA models

**CO4:** solve the spectral analysis

**CO5:** solve parameter estimation and forecasting with ARMA models

**CSDY 351** **BUSINESS INTELLIGENCE** **L T P C**

**3 0 0 3**

**SDG: 9**

**COURSE OBJECTIVES:**

**COB1**: Understand the basics of analytics and summarize Data, Categorize Models, and techniques

**COB2**: Illustrate different models suitable for different type of data

**COB3**: Make familiar with different analytics for business platform.

**COB4**: Analyse and visualize results using data visualizationtools.

**COB5**: Emphasize various applications where BI can be used.

**MODULE I INTRODUCTION 9**

Ubiquity of Data Opportunities – Decision Making – Big Data – Data Analytic Thinking – Data Mining Process – Techniques and Technologies.

**MODULE II MODELS AND METHODS 9**

Supervised Segmentation – Visualizing Segmentation – Classification, Regression via Mathematical Functions – Time Series – Association Rules – Clustering - Generalization – Fitting and Overfitting.

**MODULE III TEXT AND WEB ANALYTICS 9**

NLP – Sentiment Analysis – Search Engines – Web Usage Mining – Social Analytics.

**MODULE IV DATA VISUALIZATION 9**

Tables – Charts –Heat Maps – GIS – Data Dashboards –Business Performance Management - Balance Score Cards.

**MODULE V BI APPLICATIONS 9**

Relational marketing- Salesforce Management –Supply Chain Optimization – Data Envelopment Analysis – Case Studies.

**L – 45; Total Hours – 45**

**TEXT BOOKS:**

1. Foster Provost and Tom Fawcett, “Data Science for Business”, O’Reilly Media, Inc., 1st Edition,2013. (ISBN 978-1-449-36132-7)
2. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, Dennis J. Sweeney, Thomas A.

Williams “Business Analytics”, Cengage Learning, Inc., 3rd Edition, 2018. (ISBN 978-1-337-40642-0)

**REFERENCES:**

1. Drew Bentley, “Business Intelligence and Analytics”, Library Press, Inc., 1st Edition,2017. (ISBN 978-1-9789-2136-8)
2. Ramesh Sharda, DursunDelen, Efraim Turban, “Business Intelligence a Managerial Perspective on Analytics”, Pearson Publications, 3rd Edition, 2017. (ISBN 978-9352862719)
3. Carlo-Vercellis, “Business Intelligence Data Mining and Optimization for Decision-Making”, Wiley Publications, 1st Edition, 2013. (ISBN 978-8126541881)

**COURSE OUTCOMES:**

**CO1**: Comprehend the fundamentals of BI & data analytics and the corresponding terminologies

**CO2**: Develop predictive models for various Real-Time Applications

**CO3**: Illustrate competently on the topic of analytics

**CO4**: Understand & Implement different visualization techniques for various datasets.

**CO5**: Demonstrate the real time scenario by using BI & Analyticstechniques

**Board of Studies (BoS) :**
18th BoS of CSE held on 26.06.2021

**Academic Council:**
17th AC held on 15.07.2021

| | PO1 | PO2 | PO3 | PO4 |
|---|---|---|---|---|
| CO1 | L | | H | |
| CO2 | | M | | H |
| CO3 | | M | | |
| CO4 | | | H | H |
| CO5 | | | H | H |

SDG 9 : Build resilient Infrastructure, promote inclusive and sustainable industrialization and foster innovation

Statement: Implementing data analytics in small and medium-sized enterprises can improve production, create new goods and services, improve processes and marketing strategies. Data analytics, if well harnessed, can also help SMEs overcome disadvantages related to scale.

**CSDY 352** **ARTIFICIAL INTELLIGENCE** **L T P C**

**3 0 0 3**

**SDG: 9**

**COURSE OBJECTIVES:**

**COB1**: To study the notions of state space representation and exhaustive search techniques

**COB2**: To understand the logical imputations in computational intelligence.

**COB3**: To understand the various automated learning techniques.

**COB4**: To study the application of knowledge representation and reasoning in Planning.

**COB5**: To explore the real time applications of AI.

**MODULE I INTELLIGENT AGENTS AND KNOWLEDGE REPRESENTATION** **9**

Structure of Intelligent agents - Environments -Knowledge based agent- Real-World Knowledge Representation - Knowledge representation Techniques.

**MODULE II PROBLEM SOLVING** **9**

Solving problem by search – Searching tree representation - Informed search - Uninformed Search – Game playing -Constraint Satisfaction - Means Ends Analysis.

**MODULE III LOGICAL REASONING** **9**

Logical Agent – Reasoning in AI - Propositional Logic - Rules of Inference- Knowledge Engineering in First - order logic - Inference in First - Order Logic.

**MODULE IV PLANNING IN ARTIFICIAL INTELLIGENCE** **9**

Planning Representation – Planning vs Problem Solving – Planning Domain- Partial-Order Planning - Planning with State-Space Search - Hierarchical Planning - Conditional Planning - Replanning - Graph Planning - Multiagent Planning - Automated Planning.

**MODULE V LEARNING** **9**

Learning from Observation – knowledge in Learning – statistical Learning models in AI - Learning in Neural and Belief Networks - Reinforcement Learning.

**L - 45; Total Hours - 45**

**TEXT BOOKS:**

1. Chowdhary K.R. “Fundamentals of Artificial Intelligence”, Springer India, ISBN: 978-81-322-3970-3, 2020.

**REFERENCES:**

1. SunilkumarManvi, Gopal Shyam, “Cloud Computing Concepts and Technologies”, First Edition, CRC Press, SBN: 9781000337952, 1000337952, 2021.
2. Denis Rothman, “Artificial Intelligence By Example: Acquire Advanced AI, Machine Learning, and Deep Learning Design Skills”, Packt Publishing, 2nd Edition, ISBN: 9781839211539, 2020.
3. Melanie Mitchell, “Artificial Intelligence: A Guide for Thinking Humans” Picador, ISBN-13:9781250758040, 2020.

**COURSE OUTCOMES:**

**CO1**: Understand problem solving, reasoning, planning, natural language understanding and automatic programming.

**CO2**: Explore the search techniques and apply the search techniques to real–time problems.

**CO3**: Understand of the design of intelligent computational agents.

**CO4**: Develop the ability to understand Capacity planning, SLA management and Resource Management

**CO5**: Analyze and apply the reasoning techniques to real world problems.

**Board of Studies (BoS) :**
18th BoS of CSE held on 26.06.2021

**Academic Council:**
17th AC held on 15.07.2021

| | PO1 | PO2 | PO3 | PO4 |
|---|---|---|---|---|
| CO1 | | M | M | |
| CO2 | | M | M | |
| CO3 | | | H | H |
| CO4 | | | M | H |
| CO5 | H | | | H |

SDG 9: Build resilient Infrastructure, promote inclusive and sustainable industrialization and foster innovation

Statement: Artificial Intelligence has enormous potential catering to various aspects of the world – be it economic, social, environment related, or anything for that matter. AI along with machine learning approaches can help taking decisions based on data easier than ever.

| CSDY 301 | SQL FOR DATA SCIENCE | L | T | P | C |
|---|---|---|---|---|---|
| SDG: 2 | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

**COB1:** Learn structured query language (SQL) to an intermediate/advanced level.

**COB2:** Be able to write data retrieval queries and evaluate the result set.

**COB3:** Understand the structure and design of relational databases.

**COB4:** Understand the importance and major issues of database security and the maintenance of data integrity.

**COB5:** Provide expertise to plan, organize, direct and lead full-scale data analytics projects and business ventures.

**MODULE I UNDERSTANDING AND DESCRIBING DATA 9**

Introduction – Methods of descriptive statics - Reletional database and SQL– Basic types of SQL – Creating table- Updating table–Deleting data and tables– SQL and analytics.

**MODULE II SQL FOR DATA PREPARATION 9**

Assembling Data – Connecting tables using join – Types of join – Sub Queries – Unions – Transforming data.

**MODULE III AGGREGATE FUNCTIONS AND DATA ANALYSIS 9**

Aggregate function – Aggregate functions with group by – The HAVING Clause – Windows Functon – Statistics with window function – Importing and Exporting data.

**MODULE IV ANALYTICS USING COMLEX DATA TYPES 9**

Date and time data types for analysis– Performing geospatialanalysis in postgres- Using array data Types in postgres – Using JSON data Types in postgres – Test analytics in post.

**MODULE V DATA WRANGLING 9**

Reshaping Data – Joining Tables – Web scarping- String processing – string package –Testing and improving –Casestudy.

**L – 45; Total Hours – 45**

**TEXT BOOKS:**

1. Upom Malik, Matt GoldwasseandBenjamin Johnston, ”SQL for Data Analytics :Perform Fast and Efficient Data Analysis with the Power of

SQL", Packet Publishing,1st Edition Mumbai,2019.(ISBN: 9781789803846)
2. Cathy tanimura,"SQL for Data Analysis: overview of SQL",O Really Media publisher, 5th Edition,US,2021.(ISBN: 9781492088783)

**REFERENCES:**

1. Rafael. AIrizarry., "introduction to Datascience: Data Analysis and prediction algorithm with R", CRCP press Publisher, US , 2019 .(ISBN :9780429341830)

**COURSE OUTCOMES:**

**CO1**: Identify the knowledge and understanding of Database analysis and design.

**CO2**: Develop programming and software Engineering Skills and techniques using SQL and PL/SQl.

**CO3**: Design and develop a SQL Data Environment according to the benchmarks

**CO4**: Analyze the data using various statistical methods.

**CO5**: Develop applications using large scale analytics tools to solve open data analytics problems

**Board of Studies (BoS) :**
18th BoS of CSE held on 26.06.2021

**Academic Council:**
17th AC held on 15.07.2021

| | PO1 | PO2 | PO3 | PO4 |
|---|---|---|---|---|
| CO1 | L | | | |
| CO2 | | | | |
| CO3 | | | L | |
| CO4 | M | | | |
| CO5 | | | | H |

SDG 2: Zero Hunger.

Statement: This SDG with data science is MEANS Which uses a system of emails, text and cloud-based data crunching to match right food to the right needy people.

(Ex.: The problem that MEANS is attempting to solve is the mismatch of food between what food kitchens and charities need and what is being given to them)

| CSDY 302 | CLOUD COMPUTING AND TECHNOLOGY | L | T | P | C |
|---|---|---|---|---|---|
| SDG: 8 | | 3 | 0 | 0 | 3 |

**COURSE OBJECTIVES:**

**COB1**: To understand the concepts of Cloud Computing and its Evolution

**COB2**: To provide the knowledge on various virtualization concepts

**COB3**: To explore the different types of Cloud computing models

**COB4**: To understand the concepts of capacity planning and Resource management

**COB5**: To provide the cloud security concepts&development tools in cloud computing

**MODULE I INTRODUCTION** **9**

Introduction – Cloud Computing, Service delivery models, Deployment Models- Characteristics and Benefits of Cloud computing, Cloud computing platforms and technologies – Distributed and Parallel Computing – Distributed computing and its properties, Performance consideration in distributed Computing, Parallel Computing, performance consideration in parallel computing, Amdahl's law, Flynn's classical taxonomy, Classes of parallel computers – Multi core Architecture - Multi cores in cloud computing, Classes of parallelism, Limitations.

**MODULE II VIRTUALIZATION** **9**

Virtualization – Defining virtualization, Virtualization models, Server virtualization models, Desktop virtualization, Application virtualization- Hardware Maximization – Move to 64 bit, Rely on shared storage, Architectures, Manage virtualization.

**MODULE III CLOUD COMPUTING MODELS** **9**

Infra structure-as-a-Service(IaaS)-IaaS in cloud, Benefits, Management of VMs in IaaS, IaaS Providers, Key to successfully moving to IaaS, Challenges of Iaas – SaaS and PaaS in cloud – Characteristics, implementation, advantages and disadvantages of SaaS, Characteristics, implementation, advantages and disadvantages of PaaS.

**MODULE IV CAPACITY PLANNING, SLA MANAGEMENT AND RESOURCE MANAGEMENT** **9**

Cloud capacity models, probabilistic auto-scaling for capacity planning – SLA

Management – Components of SLA, Life Cycle of SLA, SLA Management system in Cloud – Resource Management in Cloud – Significant resources, Issues and Solutions.

**MODULE V CLOUD COMPUTING SECURITY & DEVELOPMENT TOOLS** 9

Cloud security – Data Security, Encryption techniques in Cloud, Infra Structure security, PaaS Application security, SaaS Application security, Securing virtual servers, Cloud Security controls - Cloud computing Development - Kernel Virtual Machine, Delta Cloud, Eucalyptus, OpenStack, SaltStack, ApacheCloudStack, AWS Cloud Development Kit(AWS CDK), Windows Azure SDK

**L - 45; Total Hours - 45**

**TEXT BOOKS:**

1. SunilkumarManvi, Gopal Shyam, “Cloud Computing Concepts and Technologies”, First Edition, CRC Press, SBN: 9781000337952, 1000337952, 2021.
2. Dac-Nhuong Le, Raghvendra Kumar, Gia Nhu Nguyen, Jyotir Moy Chatterjee, “Cloud Computing and Virtualization”, Wiley, 2018, SBN:9781119488125, 1119488125

**REFERENCES:**

1. Dinesh G. Harkut, KashmiraKasat, Saurabh Shah, “Cloud Computing Technology and Practices”, Intechopne, 2019, ISBN:9781789849158, 1789849152

**COURSE OUTCOMES:**

**CO1**: Articulate the main concepts of cloud computing.

**CO2**: Illustrate the concepts of virtualization.

**CO3:** Develop the ability to understand and use the Cloud computing models.

**CO4**: Develop the ability to understand Capacity planning, SLA management and Resource Management.

**CO5:** Explain the use various cloud computing development tools.

**Board of Studies (BoS) :**
18th BoS of CSE held on 26.06.2021

**Academic Council:**
17th AC held on 15.07.2021

| | PO1 | PO2 | PO3 | PO4 |
|---|---|---|---|---|
| CO1 | M | L | L | |
| CO2 | M | | M | M |
| CO3 | M | L | H | M |
| CO4 | M | L | M | M |
| CO5 | M | L | H | H |

SDG 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.

Statement: By learning “Cloud Computing and Technology”, the students will be able to discuss economic models and future visions of economy and society critically and to communicate them in public spheres.