# Miracle Educational Society Group of Institutions

**(Autonomous)**

(Approved by AICTE.New Delhi,Accredited by NAAC & Permanently Affiliated to JNTU GV)

Miracle City,Bhogapuram,Vizianagaram-535216

# Department of Artificial Intelligence and Data Science

## M.Tech

## R-25 Regulation

## *BOS Approved Course Structure & Syllabus*

MIRACLE Educational Society Group of Institutions

An Autonomous Institution

Approved by AICTE, New Delhi
Permanently Affiliated to JNTUGV
Accredited by NAAC (UGC)
Recognized by UGC Under Section 2(f)

Date: 08.01.2026

Department of Artificial Intelligence & Data Science

Minutes of the 2nd Board of Studies (BOS) Meeting held on 08.01.2026

**Agenda:**

1. Welcoming distinguish invitees of BoS by the AI&DS- HoD
2. Discussion about the B.Tech - AI&DS(3rd&4th year) course structure.
3. Discussion about the 3rd&4th year syllabus of B.Tech - AI&DS
4. Discussion about the M.Tech - AI&DS course structure.
5. Discussion about the 1st and 2nd year syllabus of M.Tech - AI&DS.
6. Discussion about the semester wise syllabus
7. Suggestions by the members

| SNO | NAME OF THE MEMBER | DESIGNATION | SIGNATURE |
|---|---|---|---|
| 1 | Dr.R. Rajeswara Rao<br>Professor, JNTUGV | University Nominee | |
| 2 | Dr.U D Prasanna<br>Professor,AITAM,Tekkali | Subject Expert | |
| 3 | Dr.G.Srinivas<br>Professor,ANITS,Visakhapatnam | Subject Expert | |
| 4 | Girish Minte | Industry Expert | |
| 5 | Mr. L Chanakya | Alumini | online. |
| 6 | Dr.A.V. Mahesh | Internal Member | |
| 7 | Mr.B. SaiPrasad | Internal Member | |
| 8 | Mrs.Bh. Vijayalaxmi | Internal Member | |
| 9 | Mrs.K.BabyKumari | Internal Member | |
| 10 | Ms.AyeshaBegum | Internal Member | |
| 11 | Mrs.K.Jhansi | Internal Member | |
| 12 | Mrs.D.Laxmi | Internal Member | |
| 13 | Mr.L.JagaJeevan Rao<br>Head of the Department- AI&DS | BOS Chairman | |

The BoS Chairman warmly welcomed all the honourable members of the Board of Studies and formally introduced them by presenting a brief overview of their biographies and notable accomplishments. He expressed his sincere gratitude to all members for graciously accepting the invitation to serve on the Board of Studies.

On behalf of the entire faculty, the Chairman conveyed heartfelt thanks for the members' valuable insights, constructive suggestions, expert guidance, and continued support, as well as for their keen interest in the overall development and progress of the department. He sought their continued cooperation and

**Academic - In charge** **DEAN** **Principal**

encouragement in establishing the AI & DS department as a leading centre of excellence and in nurturing technically competent graduates capable of competing at a global level.

The Chairman further expressed his deep appreciation for the members' active participation, thoughtful deliberations, and willingness to devote their time and expertise towards achieving academic excellence. He then read out the agenda items and formally initiated the proceedings of the Board of Studies meeting.

**Suggestion given by BOS Members:**

1.Dr. R. Rajeswara Rao garu has suggested taking the advantage of 20% deviation in the syllabus. The committee has unanimously resolved to take advantage of 20% deviation in syllabus from next academic year onwards and will be the agenda for second BOS meeting.

2. Dr. G. Srinivas sir has recommended, and curriculum refinements like replacing IoT with Machine Learning or Soft Computing, with an agreement to implement Soft Computing.

3. Dr. R. Rajeswara Rao Garu has suggested Academic enhancements, such as the introduction of MOOCs and NPTEL courses (including short-term courses of a minimum of 12 weeks).

4. Dr. U. D. Prasanna Sir suggested introducing industry-oriented and placement-focused courses to meet industry expectations and enhance students' employability, thereby better satisfying company requirements during campus placements.

5. All the BOS members accepted theB.Tech, MOOCS courses as Modern computer vision(PE-3)Cloud computing(PE-5),

**Head of the Department**

**Academic - In charge** **DEAN** **Principal**

# Miracle Educational Society Group of Institutions (A)
# Bhoghapuram-535216
# Department of Artificial Intelligence & Data Science

**Academic Regulations of M. Tech (Regular/Full Time) Programmes, 2025-26 (R25)**
**Under Choice Based Credit System (CBCS) 2025-26 (R25)**
**(Effective for the students admitted into I Year from the Academic Year 2025-26 and onwards)**

**1.0** **Post-Graduate Degree Programmes in Engineering & Technology (PGP in E & T) Miracle Educational Society Group Of Institutions** offers **Two** Years (**Four** Semesters) full-time Master of Technology (M.Tech.) Degree programmes, under Choice Based Credit System (CBCS) at its constituent (non-autonomous) and affiliated colleges in different branches of Engineering and Technology with different specializations.

**2.0** **Eligibility for Admissions**

**2.1** Admission to the PGPs shall be made subject to eligibility, qualification and specializations prescribed by the University from time to time, for each specialization under each M. Tech programme.

**2.2** Admission to the post graduate programme shall be made on the basis of either the merit rank or Percentile obtained by the qualified student in the relevant qualifying GATE Examination/ the merit rank obtained by the qualified student in an entrance test conducted by Andhra Pradesh State Government (PGECET) for M. Tech. programmes / an entrance test conducted by JNTU-GV/ on the basis of any other exams approved by the University, subject to reservations as laid down by the Govt. from time to time.

**2.3** The medium of instructions for all PG Programmes will be **ENGLISH** only.

**3.0** **M. Tech. Programme (PGP in E & T) Structure**

**3.1** The M. Tech. Programs in E & T of JNTU-GV are of Semester pattern, with **Four** Semesters consisting of **Two** academic years, each academic year having **Two** Semesters (First/Odd and Second/Even Semesters). Each Semester shall be of 22 weeks duration (inclusive of Examinations), with a minimum of 90 instructional days per Semester.

**3.2** The two-year M. Tech. program consists of **80** credits and the student has to register for all **80** credits and earn all **68** credits for the award of M. Tech. degree. There is **NO** exemption of credits in any case.

**3.3** The student shall not take more than four academic years to fulfill all the academic requirements for the award of M. Tech. degree from the date of commencement of first year first semester, failing which the student shall forfeit the seat in M. Tech. programme.

**3.4** **UGC/AICTE** specified definitions/descriptions are adopted appropriately for various terms and abbreviations used in these PG academic regulations, as listed below:

**3.4.1** **Semester Scheme**

Each Semester shall have 'Continuous Internal Evaluation (CIE)' and 'Semester End Examination (SEE)'. Choice Based Credit System (CBCS) and Credit Based Semester System (CBSS) are taken as 'references' for the present set of Regulations. The terms 'SUBJECT' and 'COURSE' imply the same meaning here and refer to 'Theory Subject', or 'Lab Course', or 'Design/Drawing Subject', or 'Mini Project with Seminar', or 'Dissertation', as the case may be.

### 3.4.2 Credit Courses

All subjects/courses are to be registered by the student in a semester to earn credits which shall be assigned to each subject/course in an L: T: P: C (Lecture Periods: Tutorial Periods: Practical Periods: Credits) structure based on the following general pattern: One credit for one hour/week/semester for theory/lecture (L) courses

- One credit for two hours/ week/semester for laboratory/ practical (P) courses or tutorials (T)

Other student activities like study tour, guest lecture, conference/workshop participations, technical paper presentations and mandatory courses (***Non-credit Audit Courses***) will not carry any credits.

### 3.4.3 Subject Course Classification

All subjects/courses offered for the Post-Graduate Programme in E & T (M. Tech. Degree Programme) are broadly classified as follows. The College has followed in general the guidelines issued by AICTE/UGC.

| S. No. | Broad Course Classification | Course Group/ Category | Course Description |
|---|---|---|---|
| 1 | Core Courses (CoC) | PC- Professional Core | Includes subjects related to the parent discipline/department/ branch of Engineering |
| | | Dissertation | M. Tech. Project or PG Project or Major Project |
| | | Mini Project with Seminar | Seminar based on core contents related to Parent Discipline/ Department/ Branch of Engineering |
| 2 | Elective Courses (EtE) | PE - Professional Electives | Includes elective subjects related to the parent discipline/department/branch of Engineering |
| | | OE - Open Electives | Elective subjects which include inter-disciplinary subjects or subjects in an area outside the parent discipline/department/ branch of Engineering |
| 3 | ***Mandatory Courses*** | -- | ***Non-Credit Audit Courses*** |

## 4.0 Course Registration

**4.1** A 'Faculty Advisor or Counselor' shall be assigned to each specialization, who will advise on the Post Graduate Programme (PGP), its Course Structure and Curriculum, Choice/Option for Subjects/ Courses, based on his competence, progress, pre-requisites and interest.

**4.2** The Academic Section of the College invites 'Registration Forms' from students within 15 days from the commencement of class work through 'ON-LINE SUBMISSIONS', ensuring 'DATE and TIME Stamping'. The ON-LINE Registration Requests for any 'CURRENT SEMESTER' shall be completed BEFORE the commencement of SEEs (Semester End Examinations) of the 'PRECEDING SEMESTER'.

**4.3** A Student can apply for ON-LINE Registration, ONLY AFTER obtaining the 'WRITTEN APPROVAL' from his Faculty Advisor, which should be submitted to the College Academic Section through the Head of Department (a copy of it being retained with Head of Department, Faculty Advisor and the Student).

**4.4** If the Student submits ambiguous choices or multiple options or erroneous entries during ON-LINE Registration for the Subject(s) / Course(s) under a given/ specified Course Group/ Category as listed in the Course Structure, only the first mentioned Subject/ Course in that Category will be taken into

consideration.

**4.5** Subject/ Course Options exercised through ON-LINE Registration are final and CANNOT be changed, nor can they be inter-changed; further, alternate choices also will not be considered. However, if the Subject/ Course that has already been listed for Registration by the University in a Semester could not be offered due to unforeseen or unexpected reasons, then the Student will be allowed to have alternate choice either for a new Subject, if it is offered, or for another existing Subject (subject to availability of seats). Such alternate arrangements will be made by the Head of Department, with due notification and time-framed schedule, within the FIRST WEEK from the commencement of Class-work for that Semester.

**5.0 Attendance Requirements**

The programmes are offered based on a unit system with each subject being considered a unit. Attendance is calculated separately for each subject.

**5.1** Attendance in all classes (Lectures/Laboratories) is compulsory. The minimum required attendance in each theory subject (***also mandatory Audit Courses***) including the attendance of mid-term examination / Laboratory etc. is 75%. Two periods of attendance for each theory subject shall be considered, if the student appears for the mid-term examination of that subject. ***This attendance should also be included in the attendance uploaded every fortnight in the University Website. The attendance of mandatory Audit Courses should be uploaded separately to the University.*** A student shall not be permitted to appear for the Semester End Examinations (SEE), if his attendance is less than 75%.

**5.2** A student's Seminar report and presentation on Mini Project shall be eligible for evaluation, only if he ensures a minimum of 75% of his attendance in Seminar presentation classes on Mini Project during that Semester.

**5.3** **Condoning of shortage of attendance** (between 65% and 75%) up to a maximum of 10% (considering the days of attendance in sports, games, NCC, NSS activities and Medical grounds) in each subject (Theory/Lab/Mini Project with Seminar) of a semester shall be granted by the College Academic Committee on genuine reasons.

**5.4** A prescribed fee per subject shall be payable for condoning shortage of attendance after getting the approval of College Academic Committee for the same. The College Academic Committee shall maintain relevant documents along with the request from the student.

**5.5** Shortage of Attendance below 65% in any subject shall in **no case be condoned.**

**5.6** A Student, whose shortage of attendance is not condoned in any Subject(s) (Theory/Lab/Mini Project with Seminar) in any Semester, is considered as 'Detained in that Subject(s), and is not eligible to write Semester End Examination(s) of such Subject(s), (in case of Mini Project with Seminar, his/her Mini Project with Seminar Report or Presentation are not eligible for evaluation) in that Semester; and he/she has to seek re-registration for those Subject(s) in subsequent Semesters, and attend the same as and when offered.

**5.7** A student fulfills the attendance requirement in the present semester, shall not be eligible for readmission into the same class.

**5.8** **a)** A student shall put in a minimum required attendance in at least **three theory subjects (excluding *mandatory (non-credit audit)* course)** in first Year I semester for promotion to first Year II Semester.

**b)** A student shall put in a minimum required attendance in at least **three theory subjects (excluding *mandatory (non-credit audit)* course)** in first Year II semester for promotion to second Year I Semester.

**6.0 Academic Requirements**

The following academic requirements must be satisfied, in addition to the attendance requirements mentioned in item no. 5. The performance of the candidate in each semester shall be evaluated subject- wise, with a maximum of 100 marks per subject / course (theory / practical), based on Internal Evaluation and Semester End Examination.

**6.1** A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/course, if he secures not less than:

- 40% of Marks (24 out of 60 marks) in the Semester End Examination;
- 40% of Marks in the internal examinations (16 out of 40 marks allotted for CIE); and
- A minimum of 50% of marks in the sum total of CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together; in terms of Letter Grades this implies securing **'B'** Grade or above in a subject.

**6.2** A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to Mini Project with seminar, if student secures not less than 50% marks (i.e. 50 out of 100 allotted marks). The student would be treated as failed, if student (i) does not submit a seminar report on Mini Project or does not make a presentation of the same before the evaluation committee as per schedule or (ii) secures less than 50% marks in Mini Project with seminar evaluation. The failed student shall reappear for the above evaluation when the notification for supplementary examination is issued.

**6.3** A student shall register for all subjects for total of **80** credits as specified and listed in the course structure for the chosen specialization, put in the required attendance and fulfill the academic requirements for securing **80** credits obtaining a minimum of **'B'** Grade or above in each subject, and all **80** credits securing Semester Grade Point Average **(SGPA) ≥ 6.0** (in each semester) and final Cumulative Grade Point Average **(CGPA)** (i.e., CGPA at the end of PGP**) ≥ 6.0**, and shall ***pass all the mandatory Audit Courses*** to complete the PGP successfully.

**Note: (1) The SGPA will be computed and printed on the marks memo only if the candidate passes in all the subjects offered and gets minimum B grade in all the subjects.**

**(2) CGPA is calculated only when the candidate passes in all the subjects offered in all the semesters**

**6.4** Marks and Letter Grades obtained in all those subjects covering the above specified **80** credits alone shall be considered for the calculation of final CGPA, which will be indicated in the Grade Card /Marks Memo of second year second semester.

**6.5** If a student registers for extra subject(s) (in the parent department or other departments/ branches of Engineering) other than those listed subjects totaling to **80** credits as specified in the course structure, the performance in extra subject(s) (although evaluated and graded using the same procedure as that of the required **80** credits) will not be considered while calculating the SGPA and CGPA. For such extra subject(s) registered, percentage of marks and Letter Grade alone will be indicated in the Grade Card/Marks Memo, as a performance measure, subject to completion of the attendance and academic requirements as stated in items 5 and 6.1 - 6.3.

**6.6** When a student is detained due to shortage of attendance in any subject(s) in any semester, no Grade allotment will be made for such subject(s). However, he is eligible for re-registration of such subject(s) in the subsequent semester(s), as and when next offered, with the academic regulations of the batch into which he is re-registered, by paying the prescribed fees per subject. In all these re-registration cases, the student shall have to secure a fresh set of internal marks and Semester End Examination marks for

performance evaluation in such subject(s), and SGPA/CGPA calculations.

**6.7** A student eligible to appear for the Semester End Examination in any subject, but absent from it or failed (failing to secure 'B' Grade or above), may reappear for that subject at the supplementary examination as and when conducted. In such cases, his Internal Marks assessed earlier for that subject will be carried over, and added to the marks secured in the supplementary examination, for the purpose of evaluating his performance in that subject.

**6.8** A Student who fails to earn **80** credits as per the specified course structure, and as indicated above, within **four** academic years from the date of commencement of his first year first semester, shall forfeit his seat in M. Tech. programme and his admission **shall stand cancelled.**

**7.0 Evaluation - Distribution and Weightage of Marks**

The performance of a student in each semester shall be evaluated subject- wise (irrespective of credits assigned) for a maximum of 100 marks.

**7.1** The performance of a student in every subject/course (including practicals and Project) will be evaluated for 100 marks each, with 40 marks allotted for CIE (Continuous Internal Evaluation) and 60 marks for SEE (Semester End-Examination). The Continuous Internal Evaluation shall be made based on the average of the marks secured in the two Mid-Term Examinations conducted, first Mid-Term examinations in the middle of the Semester and second Mid-Term examinations during the last week of instruction.

The descriptive paper shall contain 6 full questions out of which, the student has to answer 3 questions, each carrying 10 marks. The average of the two Mid Term Examinations shall be taken as the final marks for Mid Term Examination (for 30 marks).

The remaining 10 marks of Continuous Internal Assessment (out of 40) are distributed as:

1. Assignment for 5 marks. (Average of 2 Assignments each for 5 marks)
2. Subject Viva-Voce/PPT/Poster Presentation/ Case Study on a topic in the concerned subject for 5 marks.

While the first mid-term examination shall be conducted on 50% of the syllabus, the second mid-term examination shall be conducted on the remaining 50% of the syllabus.

Five (5) marks are allocated for assignments (as specified by the subject teacher concerned). The first assignment should be submitted before the conduct of the first mid-term examination, and the second assignment should be submitted before the conduct of the second mid-term examination. The average of the two assignments shall be taken as the final marks for assignment (for 5 marks).

Subject Viva-Voce/PPT/Poster Presentation/ Case Study on a topic in the concerned subject for 5 marks before II Mid-Term Examination.

- The Student, in each subject, shall have to earn 40% of marks (i.e. 16 marks out of 40 marks) in CIE, 40% of marks (i.e. 24 marks out of 60) in SEE and Overall 50% of marks (i.e. 50 marks out of 100 marks) both CIE and SEE marks taking together.

*The student is eligible to write Semester End Examination of the concerned subject, if the student scores ≥ 40% (16 marks) of 40 Continuous Internal Examination (CIE) marks.*

*In case, the student appears for Semester End Examination (SEE) of the concerned subject but not scored minimum 40% of CIE marks (16 marks out of 40 internal marks), his performance in that subject in SEE shall stand cancelled inspite of appearing the SEE.*

The details of the end semester question paper pattern are as follows:

**7.2** The Semester End Examinations (SEE), for theory subjects, will be conducted for 60 marks consisting of

- Consists of **Six** questions (numbered from 1 to 6) carrying 10 marks each. Each of these questions is from each unit and may contain sub-questions. For each question there will be an "either" "or" choice, which means that there will be two questions from each unit and the student should answer either of the two questions.
- The duration of Semester End Examination is 3 hours.

**7.3** For practical subjects there shall be a Continuous Internal Evaluation (CIE) during the semester for 40 marks and 60 marks for semester end examination. Out of the 40 marks for internal evaluation:

1. A write-up on day-to-day experiment in the laboratory (in terms of aim, components/procedure, expected outcome) which shall be evaluated for 10 marks
2. 10 marks for viva-voce (or) tutorial (or) case study (or) application (or) poster presentation of the course concerned.
3. Internal practical examination conducted by the laboratory teacher concerned shall be evaluated for 10 marks.
4. The remaining 10 marks are for Laboratory Project, which consists of the Design (or) Software / Hardware Model Presentation (or) App Development (or) Prototype Presentation submission which shall be evaluated after completion of laboratory course and before semester end practical examination.

The Semester End Examination shall be conducted with an external examiner and the laboratory teacher. The external examiner shall be appointed from the cluster / other colleges which will be decided by the examination branch.

In the Semester End Examination, held for 3 hours, total 60 marks are divided and allocated as shown below:

1. 10 marks for write-up
2. 15 for experiment/program
3. 15 for evaluation of results
4. 10 marks for presentation on another experiment/program in the same laboratory course and
5. 10 marks for viva-voce on concerned laboratory course.

- The Student, in each subject, shall have to earn 40% of marks (i.e. 16 marks out of 40 marks) in CIE, 40% of marks (i.e. 24 marks out of 60) in SEE and Overall 50% of marks (i.e. 50 marks out of 100 marks) both CIE and SEE marks taking together.

*The student is eligible to write Semester End Examination of the concerned subject, if the student scores ≥ 40% (16 marks) of 40 Continuous Internal Examination (CIE) marks.*

*In case, the student appears for Semester End Examination (SEE) of the concerned subject but not scored minimum 40% of CIE marks (16 marks out of 40 internal marks), his performance in that subject in SEE shall stand cancelled inspite of appearing the SEE.*

**7.4** For conducting laboratory end examinations of all PG Programmes, one internal examiner and one external examiner are to be appointed by the Principal of the College and this is to be informed to the Director of Evaluation within two weeks, before commencement of the lab end examinations. The external examiner should be selected from outside the College concerned but within the cluster. No external examiner should be appointed from any other College in the same cluster/any other cluster which is run by the same Management.

**7.5 Evaluation Procedure for Seminar:**

During the First Semester and Second Semester, the internal evaluation for Seminar–I and Seminar–II shall be conducted for 50 marks each.

**Procedure:** The Departmental Academic Committee (DAC) will review the progress of the Seminar during the seminar presentations in each semester and evaluate it for 50 marks. The Seminar shall be evaluated by the DAC before the semester-end examinations. The student shall carry out the Seminar in consultation with the mentor, submit the Seminar report to the department, and make an oral presentation before the DAC, which consists of the Head of the Department, the mentor, and two senior faculty members of the department.

**7.6** Every candidate shall be required to submit a dissertation on a topic approved by the Dissertation Review Committee.

**7.7** A Dissertation Review Committee (DRC) shall be constituted with the Head of the Department as Chairperson, Dissertation Supervisor and one senior faculty member of the Department offering the M.Tech. programme.

**7.8** Registration of Dissertation Work: A candidate is permitted to register for the Dissertation Work after satisfying the attendance requirement in all the subjects, both theory and laboratory.

**7.9** After satisfying 7.9, a candidate must present in ***Dissertation Work Review - I***, in consultation with his Dissertation Supervisor, the title, objective and plan of action of his Dissertation work to the Dissertation Review Committee (DRC) for approval ***within four weeks*** from the commencement of **Second year First Semester**. Only after obtaining the approval of the DRC can the student initiate the Dissertation work.

**7.10** If a candidate wishes to change his supervisor or topic of the Dissertation, he can do so with the approval of the DRC. However, the DRC shall examine whether or not the change of topic/supervisor leads to a major change of his initial plans of Dissertation proposal. If yes, his date of registration for the project work starts from the date of change of Supervisor or topic as the case may be.

**7.11** A candidate shall submit his Dissertation progress report in two stages at least with a gap of **three** months between them.

**7.12** The work on the Dissertation shall be initiated at the beginning of the II year and the duration of the Dissertation is two semesters. A candidate is permitted to submit Dissertation Thesis only after successful completion of all theory and practical courses with the approval of DRC ***not earlier than 40 weeks*** from the date of approval of the Dissertation work. For the approval of DRC, the candidate shall submit the draft copy of thesis to the Head of the Department and make an oral presentation before the DRC.

**7.13** ***The Dissertation Work Review - II*** in II Year I Semester carries 100 internal marks. Evaluation should be done by the DRC for 50 marks and the Supervisor will evaluate the work for the other 50 marks. The Supervisor and DRC will examine the Problem Definition, Objectives, Scope of Work, Literature Survey in the same domain and progress of the Dissertation Work. A candidate has to secure a minimum of 50% of marks to be declared successful in Dissertation Work Review - II. If he fails to obtain the minimum required marks, he has to reappear for Dissertation Work Review - II as and when conducted.

**7.14** ***The Dissertation Work Review - III*** in II Year II Sem. carries 100 internal marks. Evaluation should bedone by the DRC for 50 marks and the Supervisor will evaluate it for the other 50 marks. The DRC will examine the overall progress of the Dissertation Work and decide whether or not the Dissertation is eligible for final submission. A candidate has to secure a minimum of 50% of marks to be declared successful in Dissertation Work Review - III. If he fails to obtain the required minimum marks, he has to reappear for Dissertation Work Review - III as and when conducted. For Dissertation Evaluation (Viva Voce) in II Year II

Semester there are external marks of 100 and it is evaluated by the external examiner.

The candidate has to secure a minimum of 50% marks in Dissertation Evaluation (Viva- Voce) examination.

**7.15** Dissertation Work Reviews - II and III shall be conducted in phase I (Regular) and Phase II (Supplementary). Phase II will be conducted only for unsuccessful students in Phase I. The unsuccessful students in Dissertation Work Review - II (Phase II) shall reappear for it at the time of Dissertation Work Review - III (Phase I). These students shall reappear for Dissertation Work Review - III in the next academic year at the time of Dissertation Work Review - II only after completion of Dissertation Work Review - II, and then Dissertation Work Review - III follows. The unsuccessful students in Dissertation Work Review - III (Phase II) shall reappear for Dissertation Work Review - III in the next academic year only at the time of Dissertation Work Review - II (Phase I).

**7.16** After approval from the DRC, a soft copy of the thesis should be submitted for ANTI-PLAGIARISM check and the plagiarism report should be submitted to the University and be included in the final thesis. The Thesis will be accepted for submission, if the similarity index is less than **30%**. If the similarity index has more than the required percentage, the student is advised to modify accordingly and re- submit the soft copy of the thesis after one month. The maximum number of re-submissions of thesis after plagiarism check is limited to ***TWO***. The candidate has to register for the Dissertation work and work for two semesters. After three attempts, the admission is liable to be cancelled. The college authorities are advised to make plagiarism check of every soft copy of theses before submissions.

**7.17** Three copies of the Dissertation Thesis certified by the supervisor shall be submitted to the College/School/Institute, after submission of a research paper related to the Dissertation work in a UGC approved journal. A copy of the submitted research paper shall be attached to thesis.

**7.18** The thesis shall be adjudicated by an external examiner selected by the University. For this, the Principal of the College/School/Institute shall submit a panel of **three** examiners from among the list of experts in the relevant specialization as submitted by the supervisor concerned and Head of the Department.

**7.19** If the report of the external examiner is unsatisfactory, the candidate shall revise and resubmit the Thesis. If the report of the examiner is unsatisfactory again, the thesis shall be summarily rejected. Subsequent actions for such dissertations may be considered, only on the specific recommendations of the external examiner and /or Dissertation Review Committee. No further correspondence in this matter will be entertained, if there is no specific recommendation for resubmission.

**7.20** If the report of the examiner is satisfactory, the Head of the Department shall coordinate and decide for the conduct of Dissertation Viva-Voce examination. The Dissertation Viva-Voce examination shall be conducted by a board consisting of the Supervisor, Head of the Department and the external examiner who adjudicated the Thesis. The candidate has to secure a minimum of 50% of marks in Dissertation Evaluation (Viva-Voce) examination.

**7.21** If he fails to fulfill the requirements as specified in 7.21, he will reappear for the Dissertation Viva-Voce examination ***only after three months***. In the reappeared examination also, if he fails to fulfill the requirements, he will not be eligible for the award of the degree, unless he is asked to revise and resubmit his Dissertation Work by the board within a specified time period (within ***four*** years from the date of commencement of his first year first semester).

**7.22** The Dissertation Viva-Voce External examination marks must be submitted to the University on the day of the examination.

**7.23** ***For mandatory non-credit Audit courses, a student has to secure 40 marks out of 100 marks (i.e. 40% of the marks allotted) in the continuous internal evaluation for passing the subject/course. These marks should also be uploaded along with the internal marks of other subjects.***

**7.24** ***No marks or letter grades shall be allotted for mandatory non-credit Audit Courses. Only Pass/Fail shall be indicated in Grade Card.***

**8.0 Re-Admission/Re-Registration**

**8.1 Re-Admission for Discontinued Student**

A student, who has discontinued the M. Tech. degree programme due to any reason whatsoever, may be considered for '**readmission'** into the same degree programme (with the same specialization) with the academic regulations of the batch into which he gets readmitted, with prior permission from the authorities concerned, subject to item 6.6.

**8.2** If a student is detained in a subject (s) due to shortage of attendance in any semester, he may be permitted to **re-register** for the same subject(s) in the same category (core or elective group) or equivalent subject, if the same subject is not available, as suggested by the Board of Studies of that department, as and when offered in the subsequent semester(s), with the academic regulations of the batch into which he seeks re-registration, with prior permission from the authorities concerned, subject to item 3.2

**8.3** ***A candidate shall be given only one-time chance to re-register and attend the classes for a maximum of two subjects in a semester***, if the internal marks secured by a candidate are less than 40% and failed in those subjects but fulfilled the attendance requirement. A candidate must re-register for failed subjects within four weeks of commencement of the class work, in the next academic year and secure the required minimum attendance. In the event of the student taking this chance, his Continuous Internal Evaluation (internal) marks and Semester End Examination marks obtained in the previous attempt stand cancelled.

**9.0 Examinations and Assessment - The Grading System**

**9.1** Grades will be awarded to indicate the performance of each student in each Theory Subject, or Lab/Practicals, or Mini Project with Seminar, Dissertation, etc., based on the percentage of marks obtained in CIE + SEE (Continuous Internal Evaluation + Semester End Examination, both taken together) as specified in Item 7 above, and a corresponding Letter Grade shall be given.

**9.2** As a measure of the student's performance, a 10-point Absolute Grading System using the following Letter Grades (UGC Guidelines) and corresponding percentage of marks shall be followed:

| **% of Marks Secured in a subject/Course (Class Intervals)** | **Letter Grade (UGC Guidelines)** | **Grade Points** |
|---|---|---|
| 90% and above ( □ 90%, ≤ 100%) | O (Outstanding) | 10 |
| Below 90% but not less than 80% ( □80%, <90%) | $A^+$ (Excellent) | 9 |
| Below 80% but not less than 70% ( □70%, <80%) | A (Very Good) | 8 |
| Below 70% but not less than 60% ( □60%, <70%) | $B^+$ (Good) | 7 |
| Below 60% but not less than 50% ( □ 50%, <60%) | B (above Average) | 6 |
| Below 50% (< 50%) | F (FAIL) | 0 |
| **Absent** | **Ab** | **0** |

**9.3** A student obtaining **'F'** Grade in any Subject is deemed to have 'failed' and is required to reappear as 'Supplementary Candidate' for the Semester End Examination (SEE), as and when conducted. In such cases, his Internal Marks (CIE Marks) in those subjects will remain as obtained earlier.

**9.4** If a student has not appeared for the examinations, '**Ab**' Grade will be allocated to him for any subject and shall be considered 'failed' and will be required to reappear as 'Supplementary Candidate' for the

Semester End Examination (SEE), as and when conducted.

**9.5** A Letter Grade does not imply any specific marks percentage; it is only the range of percentage of marks.

**9.6** In general, a student shall not be permitted to repeat any Subject/ Course (s) only for the sake of 'Grade Improvement' or 'SGPA/ CGPA Improvement'.

**9.7** A student earns Grade Point (GP) in each Subject/ Course, on the basis of the Letter Grade obtained by him in that Subject/ Course. The corresponding 'Credit Points' (CP) are computed by multiplying the Grade Point with Credits for that particular Subject/ Course.

**Credit Points (CP) = Grade Point (GP) x Credits …. For a Course**

**9.8** The student passes the Subject/ Course only when he **gets GP ≥ 6 (B Grade or above).**

**9.9** The Semester Grade Point Average (SGPA) is calculated by dividing the Sum of Credit Points (□CP) secured from ALL Subjects/ Courses registered in a Semester, by the Total Number of Credits registered during that Semester. SGPA is rounded off to TWO Decimal Places. SGPA is thus computed as

$$\text{SGPA} = \{ \sum_{i=1}^{N} C_i G_i \} / \{ \sum_{i=1}^{N} C_i \} \text{ …. For each Semester,}$$

where 'i' is the Subject indicator index (taking into account all Subjects in a Semester), 'N' is the no. of Subjects 'REGISTERED' for the Semester (as specifically required and listed under the Course Structure of the parent Department), $C_i$ is the no. of Credits allotted to the $i^{th}$ Subject, and $G_i$ represents the Grade Points (GP) corresponding to the Letter Grade awarded for that $i^{th}$ Subject.

**9.10** The Cumulative Grade Point Average (CGPA) is a measure of the overall cumulative performance of a student over all Semesters considered for registration. The CGPA is the ratio of the Total Credit Points secured by a student in ALL registered Courses in ALL Semesters, and the Total Number of Credits registered in ALL the Semesters. CGPA is rounded off to TWO Decimal Places. CGPA is thus computed from the I Year Second Semester onwards, at the end of each Semester, as per the formula

$$\text{CGPA} = \{ \sum_{j=1}^{M} C_j G_j \} / \{ \sum_{j=1}^{M} C_j \} \text{ … for all S Semesters registered (ie., up to and inclusive of S Semesters, S ≥ 2),}$$

where 'M' is the TOTAL no. of Subjects (as specifically required and listed under the Course Structure of the parent Department) the Student has 'REGISTERED' for from the 1st Semester onwards upto and inclusive of the Semester S ( obviously M > N ), 'j' is the Subject indicator index (taking into account all Subjects from 1 to S Semesters), $C_j$ is the no. of Credits allotted to the $j^{th}$ Subject, and $G_j$ represents the Grade Points (GP) corresponding to the Letter Grade awarded for that $j^{th}$ Subject. After registration and completion of I Year I Semester however, the SGPA of that Semester itself may be taken as the CGPA, as there are no cumulative effects.

**Illustration of calculation of SGPA**

| Course/Subject | Credits | Letter Grade | Grade points | Credit Points |
|---|---|---|---|---|
| Course 1 | 4 | A | 8 | 4*8 = 32 |
| Course 2 | 4 | O | 10 | 4*10 = 40 |
| Course 3 | 4 | B | 6 | 4*6 = 24 |
| Course 4 | 3 | B | 6 | 3*6 = 18 |
| Course 5 | 3 | A+ | 9 | 3*9 = 27 |
| Course 6 | 3 | B | 6 | 3*6 = 18 |
| | 21 | | | 159 |

SGPA = 159/21 = 7.57

**Illustration of calculation of CGPA**

| Semester | Credits | SGPA | Credits * SGPA |
|---|---|---|---|
| Semester I | 24 | 7 | 24*7 = 168 |
| Semester II | 24 | 6 | 24*6 = 144 |
| Semester III | 24 | 6.5 | 24*6.5 = 156 |
| Semester IV | 24 | 6 | 24*6 = 144 |
| | 96 | | 612 |

CGPA = 612/96 = 6.37

**10.0 Award of Degree and Class**

**10.1** If a student who registers for all the specified Subjects/ Courses as listed in the Course Structure, satisfies all the Course Requirements, and passes the examinations prescribed in the entire PG Programme (PGP), and secures the required number of **80** Credits (with CGPA □6.0), shall be declared to have 'QUALIFIED' for the award of the M.Tech. Degree in the chosen Branch of Engineering and Technology with the specialization that he was admitted into.

**10.2 Award of Class**

After a student has earned the requirements prescribed for the completion of the programme and is eligible for the award of M.Tech. Degree, he shall be placed in one of the following three classes based on the CGPA:

| Class Awarded | CGPA |
|---|---|
| First Class with Distinction | ≥ 7.75 |
| First Class | 6.75≤ CGPA < 7.75 |
| Second Class | 6.00≤ CGPA < 6.75 |

A student with final CGPA (at the end of the **PGP) < 6.00** shall not be eligible for the Award of Degree.

**11.0 Withholding of Results**

If the student has not paid the dues, if any, to the University or if any case of indiscipline is pending against him, the result and degree of the student will be withheld and he will not be allowed into the next semester.

**12.0 General**

**12.1** **Credit**: A unit by which the course work is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of

practical work/field work per week.

**12.2** **Credit Point:** It is the product of grade point and number of credits for a course.

**12.3** Wherever the words "he", "him", "his", occur in the regulations, they shall include "she", "her".

**12.4** The academic regulation should be read as a whole for the purpose of any interpretation.

**12.5** In case of any doubt or ambiguity in the interpretation of the above rules, the decision of the University is final.

**12.6** The University may change or amend the academic regulations or syllabi at any time and the changes or amendments made shall be applicable to all the students with effect from the dates notified by the University.

## MALPRACTICES RULES

## DISCIPLINARY ACTION FOR IMPROPER CONDUCT IN EXAMINATIONS

| S.No | Nature of Malpractices/Improper conduct | Punishment |
|---|---|---|
| | If the candidate: | |
| 1.(a) | Possesses or keeps accessible in examination hall, any paper, note book, programmable calculators, Cell phones, pager, palm computers or any other form of material concerned with or related to the subject to the examination (theory or practical) in which he is appearing but has not made use of (material shall include any marks on the body of the candidate which can be used as an aid in the subject of the examination). | Expulsion from the examination hall and cancellation of the performance in that subject only. |
| (b) | Gives assistance or guidance or receives it from any other candidate orally or by any other body language methods or communicates through cell phones with any candidate or persons in or outside the exam hall in respect of any matter. | Expulsion from the examination hall and cancellation of the performance in that subject only of all the candidates involved. In case of an outsider, he will be handed over to the police and a case is registered against him. |
| 2. | Has copied in the examination hall from any paper, book, programmable calculators, palm computers or any other form of material relevant to the subject to the examination (theory or practical) in which the candidate is appearing. | Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted to appear for the remaining examinations of the subjects of that Semester/year. The Hall Ticket of the candidate is to be cancelled and sent to the University. |
| 3. | Impersonates any other candidate in connection with the examination. | The candidate who has impersonated shall be expelled from examination hall. The candidate is also debarred and forfeits the seat. The performance of the original candidate, who has been impersonated, shall be cancelled in all the subjects of the examination (including practicals and project work) already appeared and shall not be allowed to appear for examinations of the remaining subjects of that semester/year. The candidate is also debarred for two consecutive semesters from class work and all University examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat. If the imposter is an outsider, he will be handed over to the police and a case is registered against him. |

| | | |
|---|---|---|
| 4. | Smuggles in the Answer book or additional sheet or takes out or arranges to send out the question paper during the examination or answer book or additional sheet, during or after the examination. | Expulsion from the examination hall and cancellation of performance in that subject and all the other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year. The candidate is also debarred for two consecutive semesters from class work and all University examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat. |
| 5. | Uses objectionable, abusive or offensive language in the answer paper or in letters to the examiners or writes to the examiner requesting him to award pass marks. | Cancellation of the performance in that subject. |
| 6. | Refuses to obey the orders of the Chief Superintendent/Assistant – Superintendent/ any officer on duty or misbehaves or creates disturbance of any kind in and around the examination hall or organizes a walk out or instigates others to walk out, or threatens the officer-in charge or any person on duty in or outside the examination hall of any injury to his person or to any of his relations whether by words, either spoken or written or by signs or by visible representation, assaults the officer-in- charge, or any person on duty in or outside the examination hall or any of his relations, or indulges in any other act of misconduct or mischief which result in damage to or destruction of property in the examination hall or any part of the College campus or engages in any other act which in the opinion of the officer on duty amounts to use of unfair means or misconduct or has the tendency to disrupt the orderly conduct of the examination. | In case of students of the college, they shall be expelled from examination halls and cancellation of their performance in that subject and all other subjects the candidate(s) has (have) already appeared and shall not be permitted to appear for the remaining examinations of the subjects of that semester/year. The candidates also are debarred and forfeit their seats. In case of outsiders, they will be handed over to the police and a police case is registered against them. |
| 7. | Leaves the exam hall taking away answer script or intentionally tears of the script or any par there of inside or outside the examination hall. | Expulsion from the examination hall and cancellation of performance in that subject and all the other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year. The candidate is also debarred for two consecutive semesters from class work and all University examinations. The continuation of the course by the candidate is subject to the academic regulations in |

| | | |
|---|---|---|
| | | connection with forfeiture of seat. |
| 8. | Possess any lethal weapon or firearm in the examination hall. | Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year. The candidate is also debarred and forfeits the seat. |
| 9. | If student of the college, who is not a candidate for the particular examination or any person not connected with the college indulges in any malpractice or improper conduct mentioned in clause 6 to 8. | Student of the colleges expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year. The candidate is also debarred and forfeits the seat. Person(s) who do not belong to the College will be handed over to police and, a police case will be registered against them. |
| 10. | Comes in a drunken condition to the examination hall. | Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year. |
| 11. | Copying detected on the basis of internal evidence, such as, during valuation or during special scrutiny. | Cancellation of the performance in that subject and all other subjects the candidate has appeared including practical examinations and project work of that semester/year examinations. |
| 12. | If any malpractice is detected which is not covered in the above clauses 1 to 11 shall be reported to the University for further action to award suitable punishment. | |

**Malpractices identified by squad or special invigilators**

1. Punishments to the candidates as per the above guidelines.
2. Punishment for institutions: (if the squad reports that the college is also involved in encouraging malpractices)
   - (i) A show cause notice shall be issued to the college.
   - (ii) Impose a suitable fine on the college.
   - (iii) Shifting the examination centre from the college to another college for a specific period of not less than one year.

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# VISION AND MISSION OF THE DEPARTMENT

## Vision

To be recognized as a center of excellence in imparting quality technical education to succeed in the field of Artificial Intelligence and to develop our students as professionals in upcoming technologies with right knowledge, skills and attitude to meet global needs/challenges of the ever changing IT industry and the Society.

## Mission

To achieve professional excellence through learning practices in an environment which is congenial for technical education and there by develop competitive professionals with proper leadership, commitment and moral values.

**M.Tech**

# ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

**PROGRAMME COURSE STRUCTURE & SYLLABUS**

**R25 M.Tech Artificial Intelligence and Data Science**
**Programme Structure**

**I Semester**

| S. No. | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| 1 | Program Core – 1<br>Mathematics for Data Science | 3 | 1 | 0 | 4 |
| 2 | Program Core – 2<br>Artificial Intelligence | 3 | 1 | 0 | 4 |
| 3 | Program Core – 3<br>Programming for Data Science | 3 | 1 | 0 | 4 |
| 4 | Program Elective – I<br>• Recommender Systems<br>• Natural Language Processing<br>• Quantum Computing | 3 | 0 | 0 | 3 |
| 5 | Program Elective – II<br>• Big Data Frameworks<br>• Web Analytics<br>• Intelligent Systems | 3 | 0 | 0 | 3 |
| 6 | Laboratory – 1<br>Artificial Intelligence Lab | 0 | 1 | 2 | 2 |
| 7 | Laboratory – 2<br>Data Science Lab | 0 | 1 | 2 | 2 |
| 8 | Seminar-I | 0 | 0 | 2 | 1 |
| | **TOTAL** | **15** | **5** | **6** | **23** |

**List of Professional Elective Courses in I Semester (Electives – I & II)**

| S.No. | Course Title |
|---|---|
| 1 | Recommender Systems |
| 2 | Natural Language Processing |
| 3 | Quantum Computing |
| 4 | Big Data Frameworks |
| 5 | Web Analytics |
| 6 | Intelligent Systems |

@ Minimum 2/3 themes per elective

**II Semester**

| Sl. No. | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| 1 | Program Core – 4<br>Deep Learning | 3 | 1 | 0 | 4 |
| 2 | Program Core – 5<br>Data Visualization | 3 | 1 | 0 | 4 |
| 3 | Program Core – 6<br>Feature Engineering for Machine Learning | 3 | 1 | 0 | 4 |
| 4 | Program Elective – III<br>• Fuzzy Logic and Fuzzy Sets<br>• Social Networking and Mining<br>• Data Preparation and Analysis | 3 | 0 | 0 | 3 |
| 5 | Program Elective – IV<br>• Scalable Systems for Data Science<br>• Business Intelligence Tools<br>• Data Engineering | 3 | 0 | 0 | 3 |
| 6 | Laboratory – 3<br>Deep Learning Lab | 0 | 1 | 2 | 2 |
| 7 | Laboratory – 4<br>Data Visualization Lab | 0 | 1 | 2 | 2 |
| 8 | Seminar – II | 0 | 0 | 2 | 1 |
| | **TOTAL** | **15** | **5** | **6** | **23** |

* During the summer break, students need to pursue Summer Internship/ Industrial Training, which will be evaluated in the III Sem.

**List of Professional Elective Courses in II Semester (Electives III & IV)**

| S.No. | Course Title |
|---|---|
| 1 | Fuzzy Logic and Fuzzy Sets |
| 2 | Social Networking and Mining |
| 3 | Data Preparation and Analysis |
| 4 | Scalable Systems for Data Science |
| 5 | Business Intelligence Tools |
| 6 | Data Engineering |

@ Minimum 2/3 themes per elective

**III Semester**

| S. No. | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| 1 | Research Methodology and IPR / *Swayam 12 week MOOC course – RM&IPR* | 3 | 0 | 0 | 3 |
| 2 | Summer Internship/ Industrial Training (8-10 weeks)* | - | - | - | 3 |
| 3 | Comprehensive Viva# | - | - | - | 2 |
| 4 | Dissertation Part – A$ | - | - | 20 | 10 |
| | **TOTAL** | **3** | **-** | **20** | **18** |

* Student attended during summer / year break and assessment will be done in 3rd Sem.

# Comprehensive viva can be conducted courses completed upto second sem.

$ Dissertation – Part A, internal assessment

**IV Semester**

| Sl. No. | Course Title | L | T | P | C |
|---|---|---|---|---|---|
| 1 | Dissertation Part – B% | - | - | 32 | 16 |
| | **TOTAL** | **-** | **-** | **32** | **16** |

% External Assessment

| I Semester | MATHEMATICS FOR DATA SCIENCE | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Course Objectives:**

The objectives of this course are to

1. Understand and apply the fundamental concepts of set theory, binary operations, functions, relations, and probability theory in mathematical problem-solving.
2. Develop proficiency in calculus and differential equations, including techniques like logarithmic differentiation, partial differentiation, and maxima/minima optimization.
3. Master matrix algebra, determinants, and linear algebra, including topics such as eigenvalues, eigenvectors, and matrix diagonalization.
4. Explore the concepts of linear transformations, vector spaces, and their applications in advanced computational problems like AI and ML models.

**Course Outcomes**: On completion of this course, the student will be able to:

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Understand set theory, binary operations, and relations | K2 |
| **CO2** | Solve problems involving differentiation and integration | K3 |
| **CO3** | Apply matrix operations and linear algebra in problem-solving | K3 |
| **CO4** | Utilize linear transformations and vector spaces for mathematical modeling | K2 |
| **CO5** | Develop skills in using Boolean algebra and propositional calculus for logical reasoning | K3 |

#Based on suggested Revised BTL

**Mapping of course outcomes with program outcomes**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
|---|---|---|---|---|---|---|
| **CO1** | M | L | M | H | M | L |
| **CO2** | M | M | H | H | H | M |
| **CO3** | H | M | H | H | H | L |
| **CO4** | M | M | H | H | M | L |
| **CO5** | M | H | M | H | M | M |

- (Please fill the above with Levels of Correlation, viz., L, M, H)

| **UNIT** | **CONTENTS** | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | Set Theory: Binary Operations, Functions and Relations, Recurrencerelations and Generating Functions, Permutations and Combinations: Pigeon Hole Principle, Probability Theory, Prepositional calculus, Tautology & Contradiction, Boolean Algebra, Idea of Continuity. | 12 |

| | | |
|---|---|---|
| **UNIT – 2** | Differentiation: Logarithmic differentiation, Partial differentiation, Euler's Theorem for Homogenous Functions, Maxima and Minima. Integration: Double Integration, Range of Order of Integration, Find Ideas; Vectors: dot product, cross product, Divergence and convergence of a vector. | 12 |
| **UNIT – 3** | Matrices & Determinants: Matrix, Def., types, Addition, Subtraction, Multiplication of Matrices, Singular and Non-Singular Matrices, Rank of a Matrix, Solution of Simultaneous Equations, Cayle Hamilton Theorem, Eigen Values & Eigen Vectors, Diagonalization of a Matrix, Concept of Positive Definite, Semi Definite. | 12 |
| **UNIT – 4** | Matrix Algebra and Linear Algebra: Introduction of groups, rings and Vector Spaces. Linear Independence and Dependence of Vectors, Linear Combination. Basis and Dimension of Vector space, Sub-Space, Intersection, Union of sub Spaces. | 12 |
| **UNIT – 5** | Linear Transformation: Matrices as Linear Mapping, Kernel and Image. Statement of Rank Nullity Theorem, Singular and Non- Regular Linear Mappings. | 12 |
| | **Total** | 60 |

**Text Books:**

1. Seymour Lipschutz, Marc Lipson, "*Linear Algebra*", 6th Edition, Schaum Series, 2018.
2. Seymour Lipschutz, Marc Lipson, H. Patil, "*Discrete Mathematics*", 3rd Edition, Schaum Series, 2017.
3. Elliott Mendelson, Frank Ayres, "*Calculus*", 6th Edition, Schaum Series, 2012.
4. Philip N. Klein, "*Coding the Matrix: Linear Algebra Through Applications to Computer Science*", Newtonian Press, 2013.
5. Sheldon Axler, "*Linear Algebra Done Right*", 3rd Edition, Springer, 2015.

**Reference Books:**

1. Kenneth H. Rosen, Discrete Mathematics and Its Applications, 7th Edition, McGraw-Hill Education, 2011.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, Wiley, 2011.
3. Gilbert Strang, Introduction to Linear Algebra, 5th Edition, Wellesley-Cambridge Press, 2016.
4. Dimitri P. Bertsekas and John N. Tsitsiklis, Introduction to Probability, 2nd Edition, Athena Scientific, 2008.
5. J. Eldon Whitesitt, Boolean Algebra and Its Applications, Dover Publications, 1995.

| I Semester | ARTIFICIAL INTELLIGENCE | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Course Objectives:**

The objectives of this course are to

1. Provide students with a foundational understanding of artificial intelligence, its history, intelligent systems, and the various AI applications in real-world scenarios.
2. Introduce problem-solving techniques in AI, including state-space search, control strategies, heuristic searches, and constraint satisfaction.
3. Explore advanced topics in knowledge representation, including semantic networks, frames, and conceptual dependency theory, and their application in AI systems.
4. Study uncertainty and fuzzy logic in AI, including probability theory, Bayesian networks, and fuzzy systems, and understand their applications in decision-making processes.

**Course Outcomes**: On completion of this course, the student will be able to:

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Understand the fundamentals of AI and its history, and apply intelligent systems to real-world problems | K2 |
| **CO2** | Analyze and apply search techniques and problem-solving strategies in AI systems | K3 |
| **CO3** | Apply knowledge representation techniques like semantic networks, frames, and conceptual dependency in AI systems | K3 |
| **CO4** | Apply uncertainty measures in AI systems using probability theory, Bayesian networks, and fuzzy logic | K3 |
| **CO5** | Critically evaluate AI systems and algorithms based on problem-solving capabilities, knowledge representation, and handling of uncertainty | K4 |

#Based on suggested Revised BTL

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | L | M | M | M | L |
| **CO2** | M | M | H | H | H | M |
| **CO3** | M | M | H | H | M | L |
| **CO4** | M | M | M | H | H | M |
| **CO5** | H | M | H | H | H | M |

(Please fill the above with Levels of Correlation, viz., L, M, H)

| UNIT | CONTENTS | Contact Hours |
|---|---|---|
| **UNIT – 1** | Introduction to artificial intelligence: Introduction, history, intelligent systems, foundations of AI, applications, tic-tac-tie game playing, development of AI languages, current trends in AI, Problem solving: state-space search and control strategies: Introduction, general problem solving, characteristics of problem, exhaustive searches, heuristic search techniques, iterative-deepening a*, constraint satisfaction | 12 |
| **UNIT – 2** | Problem reduction and game playing: Introduction, problem reduction, game playing, alpha-beta pruning, two-player perfect information games, Logic concepts: Introduction, propositional calculus, proportional logic, natural deduction system, axiomatic system, semantic tableau system in proportional logic, resolution refutation in proportional logic, predicate logic | 12 |
| **UNIT – 3** | Knowledge representation: Introduction, approaches to knowledge representation, knowledge representation using semantic network, extended semantic networks for KR, knowledge representation using frames, advanced knowledge representation techniques: Introduction, conceptual dependency theory, script structure, cyc theory, case grammars, semantic web. | 12 |
| **UNIT – 4** | Uncertainty measure: probability theory: Introduction, probability theory, Bayesian belief networks, certainty factor theory, dempster-shafer theory | 12 |
| **UNIT – 5** | Fuzzy sets and fuzzy logic: Introduction, fuzzy sets, fuzzy set operations, types of membership functions, multi valued logic, fuzzy logic, linguistic variables and hedges, fuzzy propositions, inference rules for fuzzy propositions, fuzzy systems. | 12 |
| | **Total** | 60 |

**Text Books:**

1. Artificial intelligence, A modern Approach, 2nded, Stuart Russel, Peter Norvig, Prentice Hall
2. Artificial Intelligence, SarojKaushik, 1st Edition, CENGAGE Learning, 2011.

**Reference Books:**

1. Artificial intelligence, structures and Strategies for Complex problem solving, 5th Edition, George F Lugar, PEA
2. Introduction to Artificial Intelligence, Ertel, Wolf Gang, Springer, 2017
3. Artificial Intelligence, A new Synthesis, 1st Edition, Nils J Nilsson, Elsevier, 1998
4. Artificial Intelligence- 3rd Edition, Rich, Kevin Knight, Shiv Shankar B Nair, TMH
5. Introduction to Artificial Intelligence and Expert Systems, 1st Edition, Patterson, Pearson India, 2015

| I Semester | PROGRAMMING FOR DATA SCIENCE | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Course Objectives:**

The objectives of this course are to

1. Provide students with a comprehensive understanding of fundamental concepts in data science, including basic terminologies, types of data, and the steps involved in a data science workflow.
2. Introduce students to key data manipulation and analysis tools, including NumPy for arrays and vectorized computation, and Pandas for data exploration, cleaning, and wrangling.
3. Teach students effective data visualization techniques using tools like Matplotlib, Pandas, and Seaborn, and how to summarize and aggregate data.
4. Equip students with knowledge of statistical thinking, distributions, and time series analysis, enabling them to analyze data effectively and make inferences.

**Course Outcomes**: On completion of this course, the student will be able to:

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Understand basic concepts in data science, types of data, and the five steps of data science | K2 |
| **CO2** | Apply NumPy and Pandas for data exploration, cleaning, and manipulation | K3 |
| **CO3** | Create effective data visualizations and aggregate data using Matplotlib and Seaborn | K3 |
| **CO4** | Perform statistical analysis on data, including distributions and time series analysis | K3 |
| **CO5** | Analyze and interpret real-world data problems, using the entire data science pipeline | K4 |

- #Based on suggested Revised BTL

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | L | M | M | M | L |
| **CO2** | M | M | H | H | H | M |
| **CO3** | M | M | H | H | H | M |
| **CO4** | M | M | M | H | H | M |
| **CO5** | H | M | H | H | H | M |

- (Please fill the above with Levels of Correlation, viz., L, M, H)

| UNIT | CONTENTS | Contact Hours |
|---|---|---|
| UNIT – | **Introduction To Data Science:** Basic terminologies of data science, | 12 |

| | | |
|---|---|---|
| **1** | Types of data, five steps of data science, Arrays and vectorized computation using NumPy - The NumPyndarray: A multidimensional array object, Universal functions: Fast element-wise Array functions, Array-oriented Programming with arrays, File input and output with arrays, Linear algebra, pseudorandom number generation. | |
| **UNIT – 2** | **Data Exploration With Pandas:** Process of exploring data, Pandas data structures – Series, Data frame, Index objects; Essential functionality, Summarizing and computing descriptive statistics - Correlation and covariance, Unique values, Value counts and membership; Data loading, Storage, and file formats - Reading and writing data in text format, Binary data formats, Interacting with web APIs, Interacting with databases. | 12 |
| **UNIT – 3** | **Data Cleaning, Preparation And Data Wrangling :** Handling missing data, Data transformation, String manipulation - String object methods, Regular expressions, Vectorized string functions in Pandas; Data wrangling: join, Combine and reshape - Hierarchical indexing, Combining and merging datasets, Reshaping and pivoting. | 12 |
| **UNIT – 4** | **Data Visualization With Matplotlib:** Plotting and visualization- A brief matplotlib API primer, Plotting with Pandas and Seaborn, Other python visualization tools; Data aggregation and Group operations-GroupBy mechanics, Data aggregation, Apply: General split-apply-combine, Pivot tables and Cross- tabulation. | 12 |
| **UNIT – 5** | **Statistical Thinking And Time Series Analysis :** Statistical Thinking: Distributions – Representing and plotting histograms, Outliers, Summarizing distributions, Variance, Reporting results; Probability mass function; Cumulative distribution functions - Representing CDFs, Percentile based statistics, Random numbers, Comparing percentile ranks. Time Series Analysis: Date and Time data types and tools, Time series basics, Date ranges, Frequencies, and shifting, Time zone handling, Periods and period arithmetic. | 12 |
| | **Total** | 60 |

**Text Books:**

1. Wes McKinney, Python for Data Analysis, O'Reilly, 2nd Edition, 2017.
2. Alen B. Downey, Think Stats: Exploratory Data Analysis, O'Reilly Publications, 2nd Edition, 2015.

**Reference Books:**

1. SinanOzdemir, Principles of Data Science, Packt Publishers, 2nd Edition, 2018.
2. Rachel Schutt, Cathy O'Neil,Doing Data Science: Straight Talk from the Frontline, O'Reilly, 2014.

| I Semester | RECOMMENDER SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**

The objectives of this course are to

1. Introduce students to the fundamental concepts of recommender systems, including taxonomy, problem domains, and the evaluation techniques used in the field.
2. Equip students with the skills needed to implement and apply collaborative filtering algorithms, including user-based and item-based nearest-neighbor methods.
3. Provide an understanding of content-based recommender systems, including item profiles, feature extraction, user profiles, and the use of similarity-based retrieval techniques.
4. Explore advanced topics such as knowledge-based recommendation, hybrid recommender systems, and their evaluation using real-world datasets.

**Course Outcomes**: On completion of this course, the student will be able to:

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Understand the basic concepts, taxonomy, and evaluation of recommender systems. | K2 |
| **CO2** | Implement collaborative filtering algorithms for recommendation. | K3 |
| **CO3** | Implement content-based filtering and develop item/user profiles. | K3 |
| **CO4** | Design and apply knowledge-based and hybrid recommender systems. | K3 |
| **CO5** | Evaluate recommender systems using various error metrics and user-centered metrics | K4 |

#Based on suggested Revised BTL

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | L | M | M | M | L |
| **CO2** | M | M | H | H | H | M |
| **CO3** | M | M | H | H | H | M |
| **CO4** | M | M | M | H | H | M |
| **CO5** | H | M | H | H | H | M |

- (Please fill the above with Levels of Correlation, viz., L, M, H)

| UNIT | CONTENTS | Contact Hours |
|---|---|---|
| **UNIT – 1** | Basic concepts for recommender systems, detailed taxonomy of recommender systems, Evaluation of recommender systems | 12 |
| **UNIT – 2** | Collaborative filtering algorithms: User-based nearest neighbour recommendation, Itembasednearest-neighbour recommendation, Model based and pre-processing basedapproaches, Attacks on collaborative recommender systems. | 12 |
| **UNIT – 3** | Content-based recommendation: High level architecture of content-based systems, Advantages and drawbacks of content-based filtering, Item profiles, discovering features of documents, Obtaining item features from tags, Representing item profiles, Methods forlearning user profiles, Similarity based retrieval, Classification algorithms. | 12 |
| **UNIT – 4** | Knowledge based recommendation: Knowledge representation and reasoning, Constraintbased recommenders, Case based recommenders Hybrid approaches: Opportunities for hybridization, Monolithic hybridization design: Featurecombination, Feature augmentation, Parallelized hybridization design: Weighted, Switching,Mixed, Pipelined hybridization design: Cascade Meta-level, Limitations of hybridizationstrategies | 12 |
| **UNIT – 5** | Evaluating Recommender System: General properties of evaluation research, Evaluation designs, Evaluation on historical datasets, Error metrics, Decision-Support metrics, User-Centred metrics. | 12 |
| | **Total** | 60 |

**Text Books:**

1. CharuAggarwal “Recommender Systems: The Textbook,” First Edition, Springer
2. Francesco Ricci, LiorRokach, and BrachaShapira “Recommender SystemsHandbook,” First Edition, Springer

**Reference Books:**

1. RounakBanik “Hands-On Recommendation Systems with Python,” First Edition, Packt Publishing
2. Kim Falk “Practical Recommender Systems,” First Edition, Manning Publications
3. Deepak Agarwal and Bee-Chung Chen “Statistical Methods for Recommender Systems,” First Edition, Cambridge University Press

| I Semester | NATURAL LANGUAGE PROCESSING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**

The main objective of this course is to

1. Provide a foundational understanding of Natural Language Processing (NLP), its components, and different levels of language analysis.
2. Study and implement different grammatical structures and parsing techniques such as top-down, bottom-up parsing, and augmented grammars.
3. Explore the semantic interpretation of natural language, including logical forms, word senses, and the role of ambiguity in NLP tasks.
4. Understand and implement various language modeling techniques and apply them in real-world tasks, such as machine translation, multilingual retrieval, and automatic summarization.

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

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Identify and explain the basic concepts and techniques used in NLP, including different levels of language analysis (e.g., syntax, semantics, pragmatics). | K2 |
| **CO2** | Evaluate the organization and structure of NLP systems, and identify their key components and functionalities. | K3 |
| **CO3** | Implement parsing algorithms such as top-down and bottom-up parsers and analyze augmented grammars for language processing tasks. | K3 |
| **CO4** | Analyze and perform semantic interpretation, resolving ambiguities and mapping language into logical forms for deeper understanding. | K4 |
| **CO5** | Apply language models, including n-gram models, and implement multilingual information retrieval and automatic summarization systems. | K3 |

*#Based on suggested Revised BTL*

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | H | M | L | L | M | M |
| **CO2** | M | M | H | M | H | M |
| **CO3** | M | H | H | M | H | M |
| **CO4** | M | H | M | H | M | M |
| **CO5** | M | H | H | M | H | M |

**(Please fill the above with Levels of Correlation, viz., L, M, H)**

| UNIT | CONTENTS | Contact Hours |
|---|---|---|
| UNIT – 1 | **Introduction to Natural language**<br>The Study of Language, Applications of NLP, Evaluating Language Understanding Systems, Different Levels of Language Analysis, Representations and Understanding, Organization of Natural language Understanding Systems, Linguistic Background: An outline of English Syntax. | 12 |
| UNIT – 2 | **Grammars and Parsing**<br>Grammars and Parsing- Top- Down and Bottom-Up Parsers, Transition Network Grammars, Feature Systems and Augmented Grammars, Morphological Analysis and the Lexicon, Parsing with Features, Augmented Transition Networks. | 12 |
| UNIT – 3 | **Grammars for Natural Language**<br>Grammars for Natural Language, Movement Phenomenon in Language, Handling questions in Context Free Grammars, Hold Mechanisms in ATNs, Gap Threading, Human Preferences in Parsing, Shift Reduce Parsers, Deterministic Parsers. | 12 |
| UNIT – 4 | **Semantic Interpretation**<br>Semantic & Logical form, Word senses & ambiguity, The basic logical form language, Encoding ambiguity in the logical Form, Verbs & States in logical form, Thematic roles, Speech acts & embedded sentences, Defining semantics structure model theory.<br>**Language Modeling**<br>Introduction, n-Gram Models, Language model Evaluation, Parameter Estimation, Language Model Adaption, Types of Language Models, Language-Specific Modeling Problems, Multilingual and Cross lingual Language Modeling. | 12 |
| UNIT – 5 | **Machine Translation**<br>Survey: Introduction, Problems of Machine Translation, Is Machine Translation Possible, Brief History, Possible Approaches, Current Status. Anusaraka or Language Accessor: Background, Cutting the Gordian Knot, The Problem, Structure of Anusaraka System, User Interface, Linguistic Area, Giving up Agreement in Anusarsaka Output, Language Bridges.<br>**Multilingual Information Retrieval**<br>Introduction, Document Preprocessing, Monolingual Information Retrieval, CLIR, MLIR, Evaluation in Information Retrieval, Tools, Software and Resources.<br>**Multilingual Automatic Summarization**<br>Introduction, Approaches to Summarization, Evaluation, How to Build a Summarizer, Competitions and Datasets. | 12 |
| | **Total** | 60 |

**Text Books:**

1. James Allen, Natural Language Understanding, 2nd Edition, 2003, Pearson Education.
2. Multilingual Natural Language Processing Applications : From Theory To Practice-Daniel M.Bikel and ImedZitouni , Pearson Publications.
3. Natural Language Processing, A paninian perspective, Akshar Bharathi, Vineetchaitanya, Prentice –Hall of India.

**Refernces Books:**

1. Charniack, Eugene, Statistical Language Learning, MIT Press, 1993.
2. Jurafsky, Dan and Martin, James, Speech and Language Processing, 2nd Edition, PrenticeHall, 2008.
3. Manning, Christopher and Henrich, Schutze, Foundations of Statistical Natural Language Processing, MIT Press, 1999.

| I Semester | QUANTUM COMPUTING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**

The objectives of this course are to

1. Provide students with a solid foundation in the basic principles of quantum mechanics and quantum computing, including qubits, entanglement, and quantum interference.
2. Teach students how to design and implement quantum circuits and operators, with a particular focus on Grover's algorithm and its practical applications.
3. Explore the methods of storing and encoding data in quantum computers, such as amplitude encoding and dynamic encoding.
4. Introduce students to advanced quantum algorithms, including Quantum Fourier Transform, Quantum Phase Estimation, and Quantum Support Vector Machines, along with near-term algorithms for current quantum devices.

**Course Outcomes**: On completion of this course, the student will be able to:

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Understand the fundamental concepts of quantum mechanics and quantum computing. | K2 |
| **CO2** | Implement quantum circuits and algorithms. | K3 |
| **CO3** | Apply data encoding techniques on a quantum computer | K3 |
| **CO4** | Develop and implement advanced quantum algorithms. | K3 |
| **CO5** | Analyze and evaluate quantum algorithms on current quantum devices | K4 |

#Based on suggested Revised BTL

**Mapping of course outcomes with program outcomes**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
|---|---|---|---|---|---|---|
| **CO1** | M | L | M | M | M | L |
| **CO2** | M | M | H | H | H | M |
| **CO3** | M | M | H | H | H | M |
| **CO4** | M | M | H | H | H | M |
| **CO5** | H | M | H | H | H | M |

(Please fill the above with Levels of Correlation, viz., L, M, H)

| UNIT | CONTENTS | Contact Hours |
|---|---|---|
| **UNIT – 1** | Introduction to quantum mechanics: Why Quantum Computing, History of Quantum Physics, Qubits, Probabilistic interpretation, Bloch sphere, Interference, Two Qubit states, Entanglement, Qubits versus Bits. | 12 |
| **UNIT – 2** | Introduction to Quantum Computing: Forms of quantum computing, Quantum Computing: Abstraction Levels, Quantum Circuit, Quantum Operators, Single-qubit operators, Ulti-qubit operators, The Power of Quantum, Grover's algorithm. | 12 |
| **UNIT – 3** | Storing Data on a Quantum Computer: Data Representations, Basis encoding, Amplitude encoding, Dynamic encoding. | 12 |
| **UNIT – 4** | Coherent Quantum Computing: Quantum Fourier Transformation, Quantum Phase Estimation, Expectation Values, Matrix Multiplication (HLL), Quantum Random Access Memory, Quantum Support Vector Machines, Adiabatic quantum computing | 12 |
| **UNIT – 5** | Algorithms for Current and Near-Term Quantum Computing Devices: Decoherence, Quantum supremacy, NISQ, Quantum Approximate Optimization Algorithm (QAOA), Variational Quantum Linear Solver, Quantum Annealing, Cloud Quantum Computing | 12 |
| | **Total** | 60 |

**Text Books:**

1. Eric R. Johnston, NicHarrigan, Mercedes and Gimeno-Segovia "Programming Quantum Computers: Essential Algorithms and Code Samples, SHROFF/ O'Reilly.
2. Dr. Christine Corbett Moran, Mastering Quantum Computing with IBM QX: Explore the world of quantum computing using the Quantum Composer and Qiskit, Kindle Edition Packt.
3. V.K Sahni, Quantum Computing (with CD), TATA McGrawHill.
4. Phillip Kaye, Raymond Laflammeet. al., An introduction to Quantum Computing, Oxford University press, 2007. (1) Chris Bernhardt, Quantum Computing for Everyone, The MIT Press, Cambridge, 2020.
5. David McMahon-Quantum Computing Explained-Wiley-Inderscience, IEEE Computer Society (2008).

**Reference Books:**

1. Chris Bernhardt, Quantum Computing for Everyone (The MIT Press).
2. Michael A. Nielsen and Issac L. Chuang, "Quantum Computation and Information", Cambridge (2002).
3. Riley Tipton Perry, "Quantum Computing from the Ground Up", World Scientific Publishing Ltd (2012).

4. Scott Aaronson, “Quantum Computing since Democritus”, Cambridge (2013).
5. P. Kok, B. Lovett, “Introduction to Optical Quantum Information Processing”, Cambridge.
6. Quantum Computation and Quantum Information, M. A. Nielsen & I. Chuang, Cambridge University Press (2013).
7. Quantum Computing, A Gentle Introduction, Eleanor G. Rieffel and Wolfgang H. Polak MIT press (2014)

| I Semester | BIG DATA FRAMEWORKS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**

The objectives of this course are to

1. Provide students with a comprehensive understanding of the Hadoop ecosystem, focusing on HDFS architecture, data flow, and parallel processing with Hadoop.
2. Teach students the essentials of developing and deploying MapReduce applications, including cluster management, job tuning, and debugging.
3. Introduce students to Spark components and its architecture, enabling them to manage clusters and resources effectively for Big Data analytics.
4. Explore performance tuning techniques, job execution, and fault tolerance mechanisms in Spark, ensuring efficient data processing and high availability.

**Course Outcomes**: On completion of this course, the student will be able to:

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Understand the Hadoop ecosystem, HDFS architecture, and data flow | K2 |
| **CO2** | Develop and optimize MapReduce applications | K3 |
| **CO3** | Understand Spark architecture and resource management with YARN and Mesos. | K2 |
| **CO4** | Implement performance tuning and fault tolerance mechanisms in Spark jobs | K3 |
| **CO5** | Analyze and evaluate job execution in Spark, including scheduling and fault tolerance. | K4 |

#Based on suggested Revised BTL

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | M | M | L | M | L |
| **CO2** | M | M | H | H | H | M |
| **CO3** | M | M | M | M | H | M |
| **CO4** | M | M | H | H | H | M |
| **CO5** | M | M | H | H | H | M |

(Please fill the above with Levels of Correlation, viz., L, M, H)

| UNIT | CONTENTS | Contact Hours |
|---|---|---|
| UNIT – 1 | **INTRODUCTION TO HADOOP**<br>Data, Data Storage and Analysis, Querying all your data, Beyond Batch, Comparison with Other Systems, The Design of HDFS, HDFS Concepts, The Command-Line Interface, Hadoop File Systems, The Java Interface, Data Flow, Parallel Copying with distcp. | 12 |
| UNIT – 2 | **HADOOP OPERATIONS AND DEVELOPING A MAP REDUCE APPLICATION**<br>Hadoop Operations: Cluster Specification, Cluster Setup and Installation, Hadoop Configuration, Security, Benchmarking a Hadoop Cluster.<br>MapReduce Application: The Configuration API, Setting up the Development Environment, Writing a Unit Test With MRUnit, Running Locally on Test Data, Running on a Cluster, Tuning a Job, MapReduce Workflows. | 12 |
| UNIT – 3 | **CLUSTER MANAGEMENT**<br>Background, Spark Components-Driver, Workers and Executors, Configuration; Spark Standalone-Architecture, Single-Node Setup scenario, Multi Node Setup; YARN-Architecture, Dynamic Resource Allocation, Scenario; Mesos-Setup, Architecture, Dynamic Resource Allocation, Basic Setup Scenario. | 12 |
| UNIT – 4 | **PERFORMANCE TUNING**<br>Spark Execution Model, Partitioning, Shuffling Data – Shuffling and Data Partitioning, Operators and Shuffling; Serialization, Spark Cache, Memory Management, Shared Variables, Broadcast Variable, Accumulators; Data Locality. | 12 |
| UNIT – 5 | **JOB EXECUTION AND FAULT TOLERANCE**<br>**Job Execution:** Life Cycle of a Spark Job-Spark Master, Spark Driver, Spark Worker, Job Life Cycle; Job Scheduling- Scheduling Within an Application, Scheduling with External Utilities.<br>**Fault Tolerance:** Fault Tolerance-Internal and External Fault Tolerance, Service Level Agreements, Resilient Distributed Datasets, Batch versus Streaming, Testing Strategies, Recommend Configurations. | 12 |
| | **Total** | 60 |

**Text Books:**

1. Tom White, Hadoop:The Definitive Guide,O'Reilly,4th Edition,2015.
2. LlyaGanelin, EmaOr.hian, Kai Sasaki, Brennon York, Spark: Big Data Cluster Computing in Production,1st Edition,2016.

**Reference Books:**

1. Nick Pentreath,Machine Learning with Spark,PacktPublishing,2015.
2. Mohammed Guller, Big Data Analytics with Spark, Apress,2015.
3. Donald Miner, Adam Shook, Map Reduce Design Pattern, O'Reilly, 2012
4. Frank J. Ohlhorst, Big Data Analytics: Turning Big Data into Big Money, Wiley Publication, December, 2012.
5. Kevin Roebuck, Big Data: High-Impact Strategies - What You Need to Know: Definitions, Adoptions, Impact, Benefits, Maturity, Vendors, Tebbo Publisher, 2011.
6. Alex Holmes, Hadoop in Practice, Manning Publications Publisher, 2012.

| I Semester | WEB ANALYTICS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**

The objectives of this course are to

1. Introduce students to the fundamentals of web analytics, data collection methods, and tools used in analyzing web traffic and performance.
2. Provide hands-on knowledge about qualitative analysis and customer-centric strategies for improving website performance.
3. Familiarize students with various web analytics concepts such as search analytics, SEO, and PPC, and their role in improving website visibility.
4. Equip students with the skills required to implement goals and funnels, set up filters, and perform e-commerce tracking to enhance marketing strategies and attribution modeling.

**Course Outcomes**: On completion of this course, the student will be able to:

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Understand and implement basic web analytics tools and techniques | K2 |
| **CO2** | Analyze customer behavior and create surveys for web-based user feedback | K3 |
| **CO3** | Implement web analytics concepts like URLS, page views, and navigation reports. | K2 |
| **CO4** | Set up and analyze goals and funnels, implement e-commerce tracking, and perform multi-channel attribution. | K3 |
| **CO5** | Conduct search engine analytics and interpret customer behavior and campaign performance. | K4 |

#Based on suggested Revised BTL

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | M | M | L | M | L |
| **CO2** | M | M | H | H | M | M |
| **CO3** | M | M | M | M | H | M |
| **CO4** | M | M | H | H | H | M |
| **CO5** | M | M | H | H | H | M |

(Please fill the above with Levels of Correlation, viz., L, M, H)

| UNIT | CONTENTS | Contact Hours |
|---|---|---|
| **UNIT – 1** | Web Analytics: Basics, Traditional Ways, Expectations, Data Collection, Clickstream Data, Weblogs, Beacons, JavaScript Tags, Packet Sniffing, Outcomes data, Competitive data, Search Engine Data. | 12 |
| **UNIT – 2** | Qualitative Analysis, Customer Centricity, Site Visits, Surveys, Questionnaires, Website Surveys, Post visits, Creating and Running, Benefits of surveys, Critical components of successful strategy. | 12 |
| **UNIT – 3** | Web Analytic concepts, URLS, Cookies, Time on site, Page views, Understand standard reports, Website content quality, Navigation reports (top pages, top destinations, site overlay). Search Analytics, Internal search,SEO and PPC, Measuring Email and Multichannel Marketing, Competitiveintelligence and Web 2.0 Analytics, Segmentation, Connectable reports. | 12 |
| **UNIT – 4** | Search Engine Analytics: Analytics, Cookies, Accounts vs Property, Tracking Code, Tracking Unique Visitors, Demographics, Page Views & Bounce Rate Acquisitions, Custom Reporting. | 12 |
| **UNIT – 5** | Goals & Funnels, Filters, Ecommerce Tracking, Real Time Reports, Customer Data Alert, AdWords Linking, AdSense Linking, Attribution Modelling, Segmentation, Campaign Tracking, Multi-Channel Attribution. | 12 |
| | **Total** | 60 |

**Text Books:**

1. AvinashKaushik, “Web Analytics 2.0: The Art of Online Accountability and Science of Customer Centricity”, 1st Edition, Sybex, 2009.
2. Michael Beasley, “Practical Web Analytics for User Experience: How Analytics can help you Understand your Users”, 1st Edition, Morgan Kaufmann, 2013.

**Reference Books:**

1. MagySeif El-Nasr, Anders Drachen, Alessandro Canossa, “Game Analytics: Maximizing the Value of Player Data”, 1st Edition, Springer, 2013.
2. Bing Liu, “Web Data Mining: Exploring Hyperlinks, Content, and Usage Data”, 2nd Edition, Springer, 2011.
3. Justin Cutroni, “Google Analytics”, 1st Edition, O’Reilly, 2010.
4. Eric Fettman, Shiraz Asif, FerasAlhlou, “Google Analytics Breakthrough”, John Wiley & sons, 2016.

| I Semester | INTELLIGENT SYSTEMS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**

The main objectives of this course are to

1. Understand the fundamental concepts of knowledge representation and reasoning, including various knowledge representation models such as frames, semantic nets, and rules.
2. Learn about different rule-based systems, including forward and backward reasoning techniques, and their application in problem-solving through various search methods.
3. Gain proficiency in using tools like Lisp and Prolog for knowledge representation and reasoning, and understand how expert system shells can be developed and used in real-time applications.
4. Explore qualitative reasoning methods, such as qualitative simulation, and understand the application of Petri nets for intelligent control and system analysis.

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

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Demonstrate the ability to represent and reason with data in various knowledge representation schemes like semantic nets, frames, and rules. | K3 |
| **CO2** | Apply forward and backward reasoning techniques to solve real-world problems, and execute these methods through depth-first search, breadth-first search, and A* search. | K4 |
| **CO3** | Develop knowledge-based systems using tools like Lisp and Prolog, and implement expert system shells for decision-making. | K5 |
| **CO4** | Solve real-time system problems by designing intelligent subsystems and synchronizing them with real-time subsystems, using appropriate communication methods. | K4 |
| **CO5** | Analyze and apply qualitative reasoning techniques like qualitative simulation and Petri nets for intelligent control and decision-making in dynamic systems. | K4 |

*#Based on suggested Revised BTL*

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | L | M | L | M | L | H |
| **CO2** | M | L | H | M | L | M |
| **CO3** | L | M | H | H | M | L |
| **CO4** | M | L | M | H | M | M |
| **CO5** | M | M | H | L | M | H |

**(Please fill the above with Levels of Correlation, viz., L, M, H)**

| UNIT | CONTENTS | Contact Hours |
|---|---|---|
| UNIT – 1 | **Knowledge Representation:** **Data and knowledge**: Data representation and data items in traditional databases, Data representation and data items in relational databases. Rules: Logical operations, Syntax and semantics of rules, Data log rule sets ,The dependence graph of data log rule sets, Objects Frames ,Semantic nets, Solving problems by reasoning: The structure of the knowledge base, The reasoning algorithm, Conflict resolution, Explanation of the reasoning. | 12 |
| UNIT – 2 | **Rule Based Systems:** **Forward reasoning:** The method of forward reasoning, A simple case study of forward reasoning. **Backward reasoning:** Solving problems by reduction, The method of backward reasoning, A simple case study of backward reasoning, Bidirectional reasoning. Search Methods: Depth-first search, Breadth-first search, Hill climbing search, A* search. **Contradiction freeness:** The notion of contradiction freeness, Testing contradiction freeness, The search problem of contradiction freeness **Completeness:** The notion of completeness, Testing Completeness, The search problem of completeness .Decomposition of knowledge bases: Strict decomposition, Heuristic decomposition | 12 |
| UNIT – 3 | **Tools for Representation and Reasoning:** **The Lisp programming language:** The fundamental data types in Lisp, Expressions and their evaluation, Some useful Lisp primitives, Some simple examples in Lisp, The Prolog programming **Language:** The elements of Prolog programs, The execution of Prolog programs, Built-in predicates, and Some simple examples in Prolog. Expert system shells: Components of an expert system shell, Basic functions and services in an expert system shell. | 12 |
| UNIT – 4 | **Real-Time Expert Systems:** **The architecture of real-time expert systems**: The real-time subsystem, The intelligent subsystem. Synchronization and communication between real-time and intelligent subsystems:Synchronization and communication primitives, Priority handling and time-out. Data exchange between the real-time and the intelligent subsystems: Loose data exchange, The blackboardarchitecture. Software engineering of real-time expert systems: The software lifecycle of real-time expert systems, Special steps and tool, An Example of A Real-Time expert System. | 12 |
| UNIT – 5 | **Qualitative Reasoning and Petri Nets:** Sign and interval calculus, Qualitative simulation: Constraint type | 12 |

| | | |
|---|---|---|
| | qualitative differential equations, The solution of QDEs: the qualitative simulation algorithm: Initial data for the simulation, Steps of the simulation algorithm, Simulation results. Qualitative physics, Signed directed graph (SDG) models, The Notion of Petri nets, the firing of transitions, Special cases and extensions, the state-space of Petri nets the use of Petri nets for intelligent control, The analysis of Petri nets: Analysis Problems for Petri Nets, Analysis techniques. | |
| | **Total** | 60 |

**Text Books:**

1. Intelligent Control Systems-An Introduction with Examples, Katalin M. Hangos, RozáliLakner , MiklósGerzson, Kluwer Academic Publishers.

**References Books:**

1. Intelligent Systems and Control: Principles and Applications Paperback, 12 Nov 2009, Laxmidhar Behera, IndraniKar by OXFORD.
2. Intelligent Systems and Technologies Methods and Applications, Springerpublications.
3. Intelligent Systems - Modeling, Optimization and Control, Yung C. Shin andChengyingXu, CRC Press, Taylor & Francis Group, 2009

| I Semester | ARTIFICIAL INTELLIGENCE LAB | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 2 |

**Course Objectives:**

The objectives of this course are to

1. Understand and implement various search algorithms such as Depth-First Search (DFS), Breadth-First Search (BFS), A*, and Hill Climbing to solve different types of AI problems.
2. Develop problem-solving skills by implementing algorithms like Simulated Annealing, Traveling Salesman Problem, and the Wumpus World.
3. Implement classic AI problems such as the 8-puzzle, Tower of Hanoi, and Fibonacci series using suitable AI techniques and recursive approaches.
4. Understand and apply Expert Systems like JESS and RVD, along with logical programming (Prolog) for rule-based systems.

**Course Outcomes**: On completion of this course, the student will be able to:

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Apply search algorithms such as DFS, BFS, and A* to solve graph-based problems | K3 |
| **CO2** | Implement optimization algorithms like Simulated Annealing and Hill Climbing to solve complex problems | K3 |
| **CO3** | Develop solutions to classical AI problems such as the 8-puzzle, Tower of Hanoi, and Traveling Salesman Problem | K3 |
| **CO4** | Develop and apply Expert Systems (like JESS and RVD) to real-world scenarios using rule-based reasoning | K4 |
| **CO5** | Write and analyze logical programs using Prolog to perform tasks like arithmetic mean calculation and vowel checking | K2 |

#Based on suggested Revised BTL

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | M | L | H | L | M |
| **CO2** | H | M | L | H | L | M |
| **CO3** | H | L | L | H | L | M |
| **CO4** | M | H | M | M | L | M |
| **CO5** | M | L | L | H | L | M |

(Please fill the above with Levels of Correlation, viz., L, M, H)

| WEEK | List of Experiments |
|---|---|
| 1 | 1. Write a program to implementation of DFS<br>2. Write a program to implementation of BFS |
| 2 | 1. Write a Program to find the solution for traveling salesman Problem |
| 3 | 1. Write a program to implement Simulated Annealing Algorithm<br>2. Write a program to find the solution for wampus world problem |
| 4 | 1. Write a program to implement 8 puzzle problem |
| 5 | 1. Write a program to implement Tower of Hanoi problem |
| 6 | 1. Write a program to implement A* Algorithm |
| 7 | 1. Write a program to implement Hill Climbing Algorithm |
| 8 | 1. Study JESS expert system |
| 9 | 1. Write a Program to Perform Fibonacci Series<br>2. Write a Program to Check Sides of a Triangle |
| 10 | 1. Write a Program to Perform Length of List<br>2. Write a Program to Perform Reverse in List. |
| 11 | 1. Write a Prolog program to perform Arithmetic Mean.<br>2. Write a Program to Check Vowels or Not. |

**Text Books:**

1. Stuart Russell, Peter Norvig, *Artificial Intelligence: A Modern Approach*, 3rd Edition, Pearson, 2010.
2. Elaine Rich, Kevin Knight, Shivashankar B. Nair, *Artificial Intelligence*, 3rd Edition, McGraw Hill, 2009.
3. Ivan Bratko, *Prolog Programming for Artificial Intelligence*, 4th Edition, Pearson, 2011.

**Reference Books:**

1. George F. Luger, *Artificial Intelligence: Structures and Strategies for Complex Problem Solving*, 6th Edition, Pearson, 2008.
2. Patrick Henry Winston, *LISP (3rd Edition)*, Addison-Wesley, 1996.
3. Jess in Action: Rule-Based Systems in Java, by Ernest Friedman-Hill, Manning Publications, 2003.
4. Nils J. Nilsson, *Artificial Intelligence: A New Synthesis*, Morgan Kaufmann, 1998.

| I Semester | DATA SCIENCE LAB | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 2 |

**Course Objectives:**

The objectives of this course are to

1. Gain hands-on experience with NumPy for performing array computations and linear algebra operations, and applying random number generation.
2. Learn pandas for data manipulation, statistical analysis, and handling different data formats like CSV, JSON, and Excel files.
3. Practice data cleaning, preparation, and transformation, including missing data handling and text manipulation, using advanced pandas functions.
4. Explore and implement data wrangling, data visualization, and time series analysis using libraries like matplotlib and seaborn, along with advanced grouping and aggregation techniques.

**Course Outcomes**: On completion of this course, the student will be able to:

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Perform efficient array operations and linear algebra computations using NumPy, including random number generation for simulations | K3 |
| **CO2** | Manipulate and analyze data using pandas, including data selection, cleaning, aggregation, and performing statistical analysis | K3 |
| **CO3** | Demonstrate proficiency in data cleaning and preparation techniques, such as handling missing values, duplicates, and transforming datasets | K3 |
| **CO4** | Visualize data using matplotlib and seaborn for effective communication of insights, and perform complex data wrangling tasks | K4 |
| **CO5** | Perform time series analysis and implement perIod arithmetic, time zone manipulation, and frequency conversion using pandas | K3 |

#Based on suggested Revised BTL

**Mapping of course outcomes with program outcomes**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
|---|---|---|---|---|---|---|
| **CO1** | H | M | L | H | L | M |
| **CO2** | H | M | L | H | L | M |
| **CO3** | H | L | L | H | L | M |
| **CO4** | M | L | M | H | L | M |
| **CO5** | M | M | L | H | L | M |

(Please fill the above with Levels of Correlation, viz., L, M, H)

| SNO | **LIST OF EXERCISES** |
|---|---|
| **1** | Array Computations using NumPy<br>a. Perform arithmetic operationsusing array.<br>b. Perform slicing and indexing on multi-dimensional arrays.<br>c. Perform computations on multi-dimensional array using universal functions (ufunc).<br>d. Compute arithmetic mean, standard deviation, variance, percentile, minimum and maximum, cumulative sum and product using statistical functions in NumPy.<br>e. Perform set theory operations such as union, intersection, symmetric difference and fetching unique values. |
| **2** | Linear Algebra and Random Number generation using linalg and random module in NumPy<br>a. Compute dot product, vector product and inner product of two arrays.<br>b. Perform matrix operations such as multiplication, determinant, sum of diagonal elements and inverse.<br>c. Compute eigenvalues, eigenvectors and singular value decomposition for a square matrix.<br>d. Generate random samples from uniform, normal, binomial, chi-square and Gaussian distributions using numpy.random functions.<br>e. Implement a single random walk with 1000 steps using random module and extract the statistics like minimum and maximum value along the walk's trajectory. |
| **3** | Data Manipulation using pandas<br>a.Create DataFrame from List, Dict, List of Dicts, Dicts of Series and perform operations such as column selection, addition, deletion and row selection,addition and deletion.<br>b. Create a DataFrame and perform descriptive statistics functions such as sum, mean, median, mode, standard deviation, skewness, kurtosis, cumulative sum, cumulative product and percent changes.<br>c. Implement the computation of correlation and covariance by considering the DataFrames of stock prices and volumes obtained from Yahoo Finance! Using pandas-data reader package. |
| **4** | Working with different data formats using pandas<br>a. Perform reading and writing data in text format using read_csv and read_table considering any online dataset in delimited format (CSV).<br>b. Perform reading, writing and parsing data in JSON (Javascript Object Notation) format using read_json.<br>c. Perform readingand writing of Microsoft Excel Files (xslx) using read_excel. |
| **5** | Interacting with Web APIs and Databases |

| | |
|---|---|
| | a. Predict the last 30 GitHub issues for pandas using request and response object's json method. Move the extracted data to DataFrame and extract fields of interest. (Use url: 'https://api.github.com/repos/pandas-dev/pandas/issues')<br>b. Connect to any relational database using corresponding SQL drivers and perform operations such as table creation, populating the table, selecting data from table, moving data from table to DataFrame, updating records and deleting records in a table. |
| **6** | Data Cleaning and Preparation<br>a. Perform data cleaning by creating a DataFrame and identifying missing data using NA(Not Available) handling methods, filter out missing data using dropna function, fill the missing data using fillna function and remove duplicates using duplicated and drop_duplicates functions.<br>b. Perform data transformation by modifying set of values using map and replace method and create transformed version of original dataset without modification using rename method.<br>c. Create a DataFrame with normally distributed data using random sampling and detect possible outliers.<br>d. Perform text manipulation with regular expression by applying relevant regular expression methods to split a string with a variable number of whitespace characters (tabs, spaces, and newlines) and get a list of all patterns matching. |
| **7** | Data Wrangling<br>a. Perform hierarchical indexing by creating a series with a list of lists (or arrays) as the index, select subsets of data at outer and inner levels using partial indexing.<br>b. Rearrange the tabular data with hierarchical indexing using unstack and stack method.<br>c. Create two different DataFrames and merge them using index as merge key and combine data with overlap using combine_first method. |
| **8** | Perform Data Visualization with Matplotlib and SeaBorn considering online dataset for processing.<br>a. Create a Line Plot by setting the title, axis labels, ticks, ticklabels , annotations on subplots and save to a file.<br>b. Create Bar Plots using Series and DataFrame index.<br>i. Create bar plotswith a DataFrame to group the values in each row together in a group in bars side by side for each value.<br>ii. Create stacked bar plots from a DataFrame.<br>c. Create Histogram to display the value frequency and Density Plot to generate continuous probability distribution function for observed data. |

| | |
|---|---|
| | d. Create Scatter Plot and examine the relationship between two one-dimensional data series.<br>e. Create Box plots to visualize data with many categorical variables. |
| **9** | Data Aggregation<br>a. Create a tabular dataset as a DataFrame and split data into groups using groupby method including single key and multiple key values. Select group by considering single and multiple columns.<br>b. Compute summary statistics such as sum, mean and standard deviation for the grouped data using aggregate method.<br>c. Use groupby function to split data into groups based on one column, miultiple columns, compute summary statistics and perform exploratory data analysis. Consider any online dataset for processing. |
| 10 | Time Series Analysis<br>a. Create time series using datetime object in pandas indexed by timestamps.<br>b. Use pandas.date_range to generate a DatetimeIndexwith an indicated length.<br>c. Generate data ranges by setting time zone, localize time zone and convert to particular time zone using tz_convert and combine two different time zones.<br>d. Perform period arithmetic such as adding and subtracting integers from periods and construct range of periods using period_range function.<br>e. Convert Periods and Period Index objects to another frequency with as freqmethod.<br>f. Convert Series and DataFrame objects indexed by timestamps to periods with the to_period method. |

**Text Books:**

1. Wes McKinney, Python for Data Analysis, O'Reilly, 2nd Edition, 2017.
2. Alen B. Downey, Think Stats: Exploratory Data Analysis, O'Reilly Publications, 2nd Edition, 2015.

**Reference Books:**

1. SinanOzdemir, Principles of Data Science, Packt Publishers, 2nd Edition, 2018.

| II Semester | DEEP LEARNING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Course Objectives:**

The main objective of this course is to

1. Introduce the fundamental concepts of deep learning, including its history, foundational models (e.g., McCulloch-Pitts Neuron, Perceptrons), and the evolution of deep learning architectures.
2. Study optimization algorithms, activation functions, and regularization techniques used in deep learning models, ensuring effective training and generalization.
3. Understand and implement Convolutional Neural Networks (CNNs) and explore their applications in image processing tasks such as object detection and segmentation.
4. Dive into Recurrent Neural Networks (RNNs), sequence learning problems, LSTMs, GRUs, and explore advanced models such as attention mechanisms and graph neural networks (GNNs).

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

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Explain the history and evolution of deep learning models, including McCulloch-Pitts Neuron, Perceptrons, and Multi-layer Perceptrons (MLPs). | K2 |
| **CO2** | Understand and implement key neural network architectures, including Feedforward Neural Networks (FFNs), Backpropagation, and the representation power of MLPs. | K3 |
| **CO3** | Implement and apply various optimization algorithms such as Gradient Descent, Adam, and techniques like Xavier and He initialization for neural networks. | K3 |
| **CO4** | Apply Convolutional Neural Networks (CNNs) for image-related tasks, including object detection, image segmentation, and advanced architectures like ResNet and GoogleNet. | K3 |
| **CO5** | Design and implement Recurrent Neural Networks (RNNs) and advanced architectures like LSTMs, GRUs, and Encoder-Decoder models for sequence learning tasks. | K3 |

*#Based on suggested Revised BTL*

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | H | M | L | L | M | M |
| **CO2** | H | M | H | M | H | M |
| **CO3** | H | H | H | M | H | M |
| **CO4** | H | H | H | M | H | M |
| **CO5** | H | H | H | M | H | M |

**(Please fill the above with Levels of Correlation, viz., L, M, H)**

| UNIT | CONTENTS | Contact Hours |
|---|---|---|
| **UNIT – 1** | History of Deep Learning, McCulloch Pitts Neuron, Perceptrons, Perceptron Learning Algorithm, Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent, Feedforward Neural Networks (FFNs), Representation Power of FFNs, Backpropagation | 12 |
| **UNIT – 2** | Optimization algorithms and activation functions: Gradient Descent (GD), Momentum based GD, stochastic GD, mini-batch GD, Adagrad, RMSProp, Adam. Initialization techniques: Xavier and He initialization. Regularization: Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Dropout, Batch Normalization | 12 |
| **UNIT – 3** | Convolutional Neural Networks (CNN): Convolution operation, filters, Padding and Stride, Sparse Connectivity and Weight Sharing, Max Pooling and NonLinearities. Transfer Learning and pretrained CNN architectures: AlexNet, ZFNet, VGGNet, GoogleNet, ResNet. Batch Normalization, Dropout. | 12 |
| **UNIT – 4** | Basic Concepts in Object Detection: Bounding box and annotation techniques, Non-maximum suppression (NMS), R-CNN and its evolution (Fast R-CNN, Faster R-CNN), You Only Look Once (YOLO) series, Single Shot MultiBox Detector (SSD) Semantic Segmentation, U-Net and its variants image segmentation, SegNet and its architecture, Instance and Panoptic Segmentation, Mask R-CNN for instance segmentation, Metrics for performance evaluation (mAP for detection, IoU for segmentation) | 12 |
| **UNIT – 5** | Recurrent Neural Networks (RNN): Sequence Learning problems, Intuition behind RNN, sequence classification, sequence labeling, Model, Loss function, Learning algorithm, Evaluation. Vanishing and Exploding gradient. LSTMs and GRUs, Encoder Decoder models, Attention mechanism, Graph Neural Networks (GNNs). | 12 |
| | **Total** | 60 |

**Text Books:**

1. Bengio, Yoshua, Ian J. Goodfellow, and Aaron Courville. "Deep learning.", MIT Press(2015) .

**Reference Books:**

1. Bengio, Yoshua. "Learning deep architectures for AI." Foundations and trends in Machine Learning 2.1 (2009): 1127.
2. Géron, A. (2022). Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow. "O'Reilly Media, Inc.".
3. Trask, A. W. (2019). Groking deep learning. Simon and Schuster.

| II Semester | DATA VISUALIZATION | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Course Objectives:**

The objectives of this course are to

1. Understand the fundamentals of data visualization, including its history, evolution, and relationship with other fields.
2. Explore the visual perception techniques and Gestalt principles that form the foundation of effective visualization design.
3. Develop skills in creating visual representations of various data types, including one-dimensional, two-dimensional, and multi-dimensional data, as well as more complex structures like trees, graphs, and networks.
4. Apply visualization techniques for real-world data, including time-series, volumetric data, geographical maps, and simulations, with a focus on interactive and collaborative visualizations.

**Course Outcomes**: On completion of this course, the student will be able to:

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Define and explain the history, purpose, and process of data visualization. Understand Gestalt principles and visual perception concepts to create meaningful visual representations of data. | K2 |
| **CO2** | Design and implement effective one-dimensional, two-dimensional, and multi-dimensional data visualizations using appropriate visual mapping techniques. | K3 |
| **CO3** | Analyze and visualize complex structures like trees, graphs, networks, and clusters, employing interaction techniques and visualization tools for detailed data exploration. | K5 |
| **CO4** | Evaluate and interpret volumetric data, vector fields, and GIS systems, designing visualizations for collaborative analysis and data-driven decision-making. | K6 |
| **CO5** | Critically assess recent visualization trends and perception techniques, identifying appropriate data structures for different visualization applications and optimizing them for clarity and impact. | K6 |

#Based on suggested Revised BTL

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | H | M | L | M | L | M |
| **CO2** | M | H | H | M | M | M |
| **CO3** | M | H | H | H | M | L |
| **CO4** | M | M | H | H | M | H |
| **CO5** | L | H | M | M | H | H |

(Please fill the above with Levels of Correlation, viz., L, M, H)

| UNIT | CONTENTS | Contact Hours |
|---|---|---|
| **UNIT – 1** | **Introduction**: What Is Visualization?, History of Visualization, Relationship between Visualization and Other Fields. The Visualization Process, Introduction of visual perception, visual representation of data, Gestalt principles, and information overloads. | 12 |
| **UNIT – 2** | Creating visual representations, visualization reference model, visual mapping, visual analytics, Design of visualization applications | 12 |
| **UNIT – 3** | Classification of visualization systems, Interaction and visualization techniques misleading, Visualization of one, two and multi-dimensional data, text and text documents. | 12 |
| **UNIT – 4** | Visualization of groups, trees, graphs, clusters, networks, software, Metaphorical visualization | 12 |
| **UNIT – 5** | Visualization of volumetric data, vector fields, processes and simulations, Visualization of maps, geographic information, GIS systems, collaborative visualizations, Evaluating visualizations **Recent trends** in various perception techniques, various visualization techniques, data structures used in data visualization. | 12 |
| | **Total** | 60 |

**Text BookS:**

1. WARD, GRINSTEIN, KEIM.Interactive Data Visualization: Foundations, Techniques, and Applications. Natick : A K Peters, Ltd.
2. E. Tufte, The Visual Display of Quantitative Information, Graphics Press.

**E-Resources:**

1. https://kdd.cs.ksu.edu/Courses/CIS536/Lectures/Slides/Lecture-34-Main_6up.pdf

| I Semester | FEATURE ENGINEERING FOR MACHINE LEARNING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 1 | 0 | 4 |

**Course Objectives:**

The objectives of this course are to

1. Introduce students to machine learning pipelines, data transformations (like log transformations and normalization), and techniques for processing text data, including feature extraction and parsing.
2. Explore various feature scaling techniques, including Term Frequency-Inverse Document Frequency (TF-IDF), and the application of logistic regression for classification.
3. Understand and apply techniques for dimensionality reduction, such as Principal Component Analysis (PCA), and explore non-linear featurization methods such as K-Means clustering and alternative dense featurization.
4. Develop an understanding of image feature extraction methods, including SIFT and HOG, and apply deep learning techniques, particularly convolutional neural networks (CNNs) for image feature extraction and classification tasks.

**Course Outcomes**: On completion of this course, the student will be able to:

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Understand and implement the machine learning pipeline, from data preprocessing (log transformations, scaling, feature selection) to text data transformation using techniques like bag-of-words and tokenization. | K2 |
| **CO2** | Apply feature scaling techniques (e.g., TF-IDF), and implement logistic regression for classification, including regularization to improve model performance. | K3 |
| **CO3** | Implement dimensionality reduction techniques like PCA and apply nonlinear featurization methods such as K-Means clustering to enhance model performance and feature representation. | K4 |
| **CO4** | Develop image feature extraction pipelines using methods like SIFT and HOG, and implement deep learning techniques to extract and classify features from images using CNNs. | K5 |
| **CO5** | Critically evaluate and compare different feature extraction and dimension reduction techniques to select the most effective ones for various types of data (text, numerical, and image data). | K6 |

#Based on suggested Revised BTL

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | H | M | L | M | L | M |
| **CO2** | M | H | H | M | M | L |
| **CO3** | M | H | H | M | M | M |
| **CO4** | M | M | H | H | H | M |
| **CO5** | L | H | M | M | H | H |

(Please fill the above with Levels of Correlation, viz., L, M, H)

| UNIT | CONTENTS | Contact Hours |
|---|---|---|
| **UNIT – 1** | **INTRODUCTION :** Machine Learning Pipeline, Scalars, Vectors, and Spaces, Log transformation, Feature Scaling or Normalization, Feature Selection, Text Data - Bag-of-X: Turning Natural Text into Flat Vectors, Filtering for Cleaner Features, Parsing and Tokenization, Collocation Extraction for Phrase Detection. | 12 |
| **UNIT – 2** | **FEATURE SCALING :**Term Frequency & Inverse Document frequency, Scaling Bag-of-Words with Tf-Idf Transformation, Classification with Logistic Regression, Tuning Logistic Regression with Regularization, Encoding Categorical Variables, Feature Hashing, Bin Counting. | 12 |
| **UNIT – 3** | **DIMENSIONALITY REDUCTION :** Intuition, Derivation, Linear Projection, Variance and Empirical Variance, Principal Components: First Formulation, Principal Components: Matrix-Vector Formulation, General Solution of the Principal Components, Transforming Features, Whitening and ZCA, Considerations and Limitations of PCA**.** | 12 |
| **UNIT – 4** | **NONLINEAR FEATURIZATION :**K-Means Clustering, Clustering as Surface Tiling, k-Means, Featurization for Classification, Alternative Dense Featurization. | 12 |
| **UNIT – 5** | **IMAGE FEATURE EXTRACTION AND DEEP LEARNING :** Feature Extraction- SIFT and HOG, Image Gradients, Gradient Orientation Histograms, SIFT Architecture; Learning Image Features with Deep Neural Networks -Fully Connected Layers, Convolutional Layers; | 12 |
| | **Total** | 60 |

**Text Books:**

1. Alice Zheng, Amanda Casari,Feature Engineering for Machine Learning, O'Reilly Media, Inc. (ISBN: 9781491953242), 2018.
2. Kjell Johnson and Max Kuhn , Feature Engineering and Selection: A Practical Approach for Predictive Models, CRC Press, 2020.

| II Semester | FUZZY LOGIC AND FUZZY SETS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**

The objectives of this course are to

1. Introduce students to the fundamental concepts of fuzzy sets, fuzzy logic, and classical set theory, along with understanding the difference between crisp and fuzzy sets and their applications in dealing with uncertainty and imprecision.
2. Explore various operations on fuzzy sets, including fuzzy complements, t-norms, and aggregation operations, and apply them in fuzzy systems and decision-making processes.
3. Provide an in-depth understanding of fuzzy logic systems and models, including Mamdani, Sugeno, and Tsukamoto fuzzy models, and the application of fuzzy inference in real-world problems.
4. Teach students the inference mechanisms used in fuzzy systems, including conditional fuzzy propositions, fuzzy quantifiers, and input space partitioning, enabling them to develop and implement fuzzy-based decision systems.

**Course Outcomes**: On completion of this course, the student will be able to:

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Understand and explain the basic concepts of fuzzy sets, their differences from crisp sets, and alpha-cuts. | K2 |
| **CO2** | Apply operations on fuzzy sets, including fuzzy complements, t-norms, and aggregation operations, in problem-solving scenarios. | K3 |
| **CO3** | Design and implement fuzzy inference systems using Mamdani, Sugeno, and Tsukamoto fuzzy models, and evaluate their performance. | K4 |
| **CO4** | Implement and evaluate inference mechanisms for fuzzy propositions, fuzzy quantifiers, and multi-valued logic. | K5 |
| **CO5** | Develop and simulate fuzzy models for real-world applications, employing input space partitioning and fuzzy decision-making methods. | K5 |

#Based on suggested Revised BTL

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | H | M | L | M | L | M |
| **CO2** | M | H | H | M | M | L |
| **CO3** | M | H | H | M | M | M |
| **CO4** | M | H | M | M | H | M |
| **CO5** | M | M | H | H | H | M |

(Please fill the above with Levels of Correlation, viz., L, M, H)

| UNIT | CONTENTS | Contact Hours |
|---|---|---|
| **UNIT – 1** | Fuzzy Set: Introduction, uncertainty, Newtonian mechanics, Probability Theory, organized simplicity, disorganized complexity, trans computational problems. | 12 |
| **UNIT – 2** | Crisp Sets: An overview, fuzzy sets: Basic types, basic concepts. Fuzzy sets versus crisp sets, additional properties of alpha-cuts, representations of fuzzy sets. | 12 |
| **UNIT – 3** | Operations on Fuzzy sets: Types of operations, fuzzy complements, Fuzzy instructions: t-Norms. Fuzzy Unicons: t-co norms, combination of operations, aggregation operations. | 12 |
| **UNIT – 4** | Fuzzy Logic: Classical logic, logic, reasoning, propositional logic, logic operation's logic formulas, tautology, inference rules, Boolean algebra, properties of Boolean algebra, quantification, predicate logic, multi-valued logic, fuzzy propositions, fuzzy quantifiers, linguistic hedges. | 12 |
| **UNIT – 5** | Inference from conditional Fuzzy propositions, Inference from conditional and quantified propositions. Mamdani fuzzy models, Sugeno Fuzzy Models, Tsukamoto Fuzzy Model, Input space partitioning, Fuzzy modelling. | 12 |
| | **Total** | 60 |

**Textbooks:**

1. Li Min Fu," *Neural Networks in Computer Intelligence*", 1st Edition, McGraw-Hill, Inc,1994.
2. George J Klir/Bo Yuan, "*Fuzzy sets & Fuzzy Logic, Theory & Applications*", 1st Edition, PHI, 2015.
3. S.R. Jang, C.T. Sun, E. Mizutani. "*Neuro Fuzzy & Soft Computing: A Computational approach to learning & Machine Intelligence*" J Pearson Education, 1996.

**Reference Books:**

1. Lotfi A. Zadeh and George J. Klir, Fuzzy Sets, Fuzzy Logic, and Fuzzy Systems: Selected Papers by Lotfi A. Zadeh, World Scientific Publishing, 1996.
2. Timothy J. Ross, Fuzzy Logic with Engineering Applications, 4th Edition, Wiley, 2020.
3. Hans Bandemer and Siegfried Gottwald, Fuzzy Sets, Fuzzy Logic, Fuzzy Methods with Applications, Wiley, 1995.
4. Didier Dubois and Henri Prade, Fundamentals of Fuzzy Sets, Springer, 2000.
5. Krassimir T. Atanassov, Intuitionistic Fuzzy Sets: Theory and Applications, Springer, 1999.

| II Semester | SOCIAL NETWORKING AND MINING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**

The objectives of this course are to

1. Introduce students to the fundamental concepts of the Semantic Web, Social Web, and Social Network Analysis (SNA), and understand the limitations of the current web.
2. Develop students' skills in visualizing social networks using various techniques like Node-Link Diagrams, Matrix-Based Representations, and Hybrid Representations, and analyze key metrics like centrality and clustering.
3. Explore techniques for community detection and mining social networks, including node classification, evolution of web communities, and evaluating mining algorithms.
4. Enable students to perform text and opinion mining in social networks, focusing on sentiment analysis, opinion extraction, and tracking sentiment over time, using modern tools and techniques.

**Course Outcomes**: On completion of this course, the student will be able to:

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Understand the limitations of the current web, the development of the Semantic Web, and the emergence of social networks | K2 |
| **CO2** | Apply techniques for visualizing social networks, including graph representations, centrality, clustering, and matrix-based visualizations. | K4 |
| **CO3** | Perform community detection and classification in social networks, and evaluate the effectiveness of community mining algorithms. | K5 |
| **CO4** | Implement text mining techniques to extract opinions, perform sentiment classification, and track sentiment over time in social network data | K5 |
| **CO5** | Use tools like UCINET, Pajek, NodeXL, and others for real-world social network analysis. | K6 |

#Based on suggested Revised BTL

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | H | M | L | M | L | M |
| **CO2** | M | H | M | M | M | M |
| **CO3** | M | H | H | M | L | M |
| **CO4** | M | M | H | M | H | M |
| **CO5** | M | M | M | M | H | H |

(Please fill the above with Levels of Correlation, viz., L, M, H)

| UNIT | CONTENTS | Contact Hours |
|---|---|---|
| **UNIT – 1** | Introduction- Introduction to Web - Limitations of current Web, Development of Semantic Web, Emergence of the Social Web, Statistical Properties of Social Networks, Network analysis, Development of Social Network Analysis, Key concepts and measures in network analysis, Discussion networks, Blogs and online communities, Web-based networks. | 12 |
| **UNIT – 2** | Modelling and Visualization- Visualizing Online Social Networks, A Taxonomy of 26 Visualizations, Graph Representation, Centrality, Clustering, Node-EdgEVisualizing Social Networks with Matrix-Based Representations, Node-Link Diagrams, Hybrid Representations, Modelling and aggregating social network data, Random Walks and their Applications, Use of Hadoop and Map Reduce - Ontological representation of social individuals and relationships. | 12 |
| **UNIT – 3** | Mining Communities- Aggregating and reasoning with social network data, Advanced Representations, Extracting evolution of Web Community from a Series of Web Archive, Detecting Communities in Social Networks, Evaluating Communities, Core Methods for Community Detection & Mining, Applications of Community Mining Algorithms, Node Classification in Social Networks. | 12 |
| **UNIT – 4** | Text and Opinion Mining- Text Mining in Social Networks, Opinion extraction, Sentiment classification and clustering, Temporal sentiment analysis, Irony detection in opinion mining, Wish analysis, Product review mining, Review Classification, Tracking sentiments towards topics over time. | 12 |
| **UNIT – 5** | Tools for Social Network Analysis- UCINET, PAJEK, ETDRAW, StOCNET, Splus, R, NodeXL, SIENA and RSIENA - Real world Social Networks (Facebook- Twitter etc.). | 12 |
| | **Total** | 60 |

**Textbooks:**

1. Charu C. Aggarwal, "*Social Network Data Analytics*", Springer, 2011.
2. Peter Mika, "*Social Networks and the Semantic Web*", 1st Edition, Springer, 2007.
3. BorkoFurht, "*Handbook of Social Network Technologies and Applications*", 1st Edition, Springer,2010.

**Reference Books:**

1. GuandongXu, Yanchun Zhang and Lin Li, "*Web Mining and Social Networking - Techniques and Applications*", 1st Edition, Springer, 2011.
2. Giles, Mark Smith, John Yen, "*Advances in Social Network Mining and Analysis*", Springer, 2010.
3. Ajith Abraham, Aboul Ella Hassanien, VáclavSnáel, "*Computational Social Network Analysis: Trends, Tools and Research Advances*", Springer, 2009.
4. SuleGündüz-Ogüdücü, A. ŞimaEtaner-Uyar, "*Social Networks: Analysis and Case Studies*", Springer, 2014.

| II Semester | DATA PREPARATION AND ANALYSIS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**

The objectives of this course are to

1. Introduce students to the fundamental concepts of data gathering, data formats, parsing, and transformation, as well as address challenges in scalability and real-time data issues.
2. Equip students with the skills required for data cleaning, including techniques for handling inconsistent, heterogeneous, and missing data, and performing data transformation and segmentation.
3. Enable students to conduct exploratory data analysis (EDA) by applying descriptive and comparative statistics, clustering, association techniques, and generating hypotheses from the data.
4. Provide hands-on experience in developing interactive visualizations and analyze real-world datasets using R or Python.

**Course Outcomes**: On completion of this course, the student will be able to:

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Understand the concepts and techniques of data gathering and data preparation, including handling different data formats, parsing, and transformation. | K2 |
| **CO2** | Perform data cleaning by addressing inconsistent, heterogeneous, and missing data, and apply techniques for data transformation and segmentation. | K4 |
| **CO3** | Conduct exploratory data analysis using descriptive statistics, comparative statistics, clustering, association techniques, and generate hypotheses for deeper data insights. | K3 |
| **CO4** | Design and implement effective visualizations for diverse data types, including time series, geolocated data, hierarchies, and networks using tools like R and Python. | K4 |
| **CO5** | Develop interactive visualizations using R or Python and apply them to solve complex data problems, enhancing understanding through user interaction. | K5 |

#Based on suggested Revised BTL

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | M | L | L | L | M |
| **CO2** | M | H | M | L | M | M |
| **CO3** | M | H | H | M | M | L |
| **CO4** | M | M | M | H | H | M |
| **CO5** | M | M | M | M | H | H |

(Please fill the above with Levels of Correlation, viz., L, M, H)

| UNIT | CONTENTS | Contact Hours |
|---|---|---|
| **UNIT – 1** | Data Gathering and Preparation: Data formats, parsing and transformation, Scalability and real-time issues. | 12 |
| **UNIT – 2** | Data Cleaning: Consistency checking, Heterogeneous and missing data, Data Transformation and segmentation. | 12 |
| **UNIT – 3** | Exploratory Analysis: Descriptive and comparative statistics, Clustering and association, Hypothesis generation. | 12 |
| **UNIT – 4** | Visualization: Designing visualizations, Time series, Geolocated data, Correlations and connections, Hierarchies and networks, interactivity. | 12 |
| **UNIT – 5** | Visualizations using R or Python. | 12 |
| | **Total** | 60 |

**Textbooks:**

1. Glenn J. Myatt, "*Making sense of Data: A practical Guide to Exploratory Data Analysis and Data Mining*", 2nd Edition, John Wiley Publishers, 2014.

**Reference Books:**

2. Ben Fry, Visualizing Data: Exploring and Explaining Data with the Processing Environment, O'Reilly Media, 2008.
3. Nathan Yau, Data Points: Visualization That Means Something, Wiley, 2013.

| II Semester | SCALABLE SYSTEMS FOR DATA SCIENCE | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**

The objectives of this course are to

1. Understand the principles and techniques of data mining, including key algorithms for clustering, association, and anomaly detection.
2. Learn and implement MapReduce and parallel processing techniques for large-scale data analysis.
3. Explore and apply different methods for data stream mining, similarity search, and locality-sensitive hashing.
4. Develop hands-on skills in clustering, recommendation systems, and large-scale machine learning using techniques like dimensionality reduction and support vector machines (SVM).

**Course Outcomes**: On completion of this course, the student will be able to:

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Demonstrate an understanding of data mining concepts, including key algorithms such as A-Priori, clustering methods, and hash functions for indexing. | K2 |
| **CO2** | Implement MapReduce and parallel processing techniques for analyzing large-scale datasets efficiently. | K3 |
| **CO3** | Apply clustering techniques like k-means and hierarchical clustering to group and categorize data, including handling non-Euclidean spaces. | K3 |
| **CO4** | Develop recommendation systems using content-based filtering and collaborative filtering techniques, and understand dimensionality reduction methods. | K4 |
| **CO5** | Gain hands-on experience with large-scale machine learning models such as perceptrons and SVM, and understand how to implement them in distributed systems. | K5 |

#Based on suggested Revised BTL

**Mapping of course outcomes with program outcomes**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
|---|---|---|---|---|---|---|
| **CO1** | H | M | L | H | M | L |
| **CO2** | M | M | H | H | H | M |
| **CO3** | M | H | M | M | H | M |
| **CO4** | M | M | H | H | H | M |
| **CO5** | H | M | H | H | M | H |

(Please fill the above with Levels of Correlation, viz., L, M, H)

| UNIT | CONTENTS | Contact Hours |
|---|---|---|
| **UNIT – 1** | Overview of Data Mining and map-reduce, Hash Functions - Indexes, Shingling LSH, Mining Data Streams - Finding similar items near-neighbor search, shingling of documents, Similarity-Preserving Summaries of Sets, Locality-Sensitive Hashing for Documents, Distance Measures, Link-analysis Page Rank, Link spam, Hubs and authorities. | 12 |
| **UNIT – 2** | Frequent Item sets Market based model, A-Priori Algorithm, Handling larger data sets in memory, Limited-pass algorithms. | 12 |
| **UNIT – 3** | Clustering Hierarchical clustering, k-means, CURE, Clustering in Non-Euclidean Spaces, Clustering for Streams and Parallelism. | 12 |
| **UNIT – 4** | Advertising on the web Matching problem, ad-words problem, Recommendation systems - Content-Based Recommendations, Collaborative Filtering, Dimensionality Reduction. | 12 |
| **UNIT – 5** | Large-scale machine learning Parallel Implementation of Perceptrons, Parallel implementation of SVM, Dealing with High-Dimensional Euclidean Data in nearest neighbors, Distributed machine learning. | 12 |
| | **Total** | 60 |

**Text Books:**

1. Jure Leskovec, AnandRajaraman, Jerey David Ullman, "*Mining of Massive Datasets*", Cambridge University Press, 2014.
2. Jimmy Lin and Chris Dyer, "*Data-Intensive Text Processing with MapReduce*", 1st Edition, Morgan and Claypool Publishers, 2010.

**Reference Books:**

1. Sandy Ryza, Uri Laserson, Sean Owen, Josh Wills, "*Advanced Analytics with Spark: Patterns for Learning from Data at Scale*", Oreilly, 2015.
2. Ankit Jain, "*Mastering Apache Storm: Processing big data streaming in real time*", Packt Publishing, 2017.

| II Semester | BUSINESS INTELLIGENCE TOOLS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**

The objectives of this course are to

1. Understand the foundations of Business Intelligence (BI) and its role in decision making, including its concepts, benefits, and characteristics.
2. Gain knowledge of data modeling techniques for BI solutions, including business, logical, dimensional, and physical modeling.
3. Learn about the ETL (Extract, Transform, Load) process and its optimization in BI systems.
4. Explore the different aspects of business reporting, performance management, and the use of BI tools for effective decision support.
5. Understand the transition of BI processes to a product environment, including deployment, maintenance, and security in cloud-based BI solutions.

**Course Outcomes**: On completion of this course, the student will be able to:

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Explain the core concepts, characteristics, benefits, and components of Business Intelligence systems. | K2 |
| **CO2** | Model data for BI solutions using various models like Business, Logical, Dimensional, and Physical models | K3 |
| **CO3** | Design and implement ETL workflows for efficient data integration and optimization | K3 |
| **CO4** | Generate meaningful business reports and utilize BI tools for data visualization and performance management | K4 |
| **CO5** | Understand how to move BI processes to a cloud environment and maintain the system effectively in different environments. | K5 |

#Based on suggested Revised BTL

**Mapping of course outcomes with program outcomes**

| | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** |
|---|---|---|---|---|---|---|
| **CO1** | M | H | L | M | M | L |
| **CO2** | H | M | H | M | M | L |
| **CO3** | M | M | H | H | M | M |
| **CO4** | M | H | M | H | H | M |
| **CO5** | H | M | H | M | H | H |

(Please fill the above with Levels of Correlation, viz., L, M, H)

| UNIT | CONTENTS | Contact Hours |
|---|---|---|
| UNIT – 1 | **FOUNDATIONS OF BUSINESS INTELLIGENCE AND DECISION MAKING**<br>Foundations of Business Intelligence: What Is business intelligence?, BI Characteristics, Benefits of BI, BI Platform Components, BI Platform Location, BI Concepts,BI Approaches, BI Capabilities.<br>Decision Making: Introduction and Definitions, Phases of the Decision-Making Process, The Intelligence Phase, The Design Phase, The Choice Phase, The Implementation Phase, Support for various phases, Decision Support Systems: Capabilities, DSS Classifications,<br>Components of Decision Support Systems. | 12 |
| UNIT – 2 | **DATA MODELING FOR BI SOLUTIONS**<br>Modeling steps- Business Model, Logical Model, Dimensional Model, Physical Model;Defining our Model-Sales Dimension, Status Table, Currency Dimension, Customer Dimension, Employee Dimension, Product Dimension, and Time Dimension; Exploring Data Modeling Possibilities, Data Modeling Tools: Preparing the<br>ETL- Source Systems, Source Tables, Source Fields. | 12 |
| UNIT – 3 | **ETL BASICS AND OPTIMIZATIONS**<br>Details of the Solution, Open Source ETL Suites, Downloading and Installing Pentaho Data Integration. Understanding ETL Concepts-Repositories and Connections, Transformations, How to Organize a Set of Transformations in a Workflow, Create and Share a Connection, The Global Picture, The Product Parent Category Tables, The Customer and Customer Country Tables, The Employee and Employee Category and Employee Department Tables, The Fact Table, Creating the Time Dimension, Connecting All of It Up, Designing the Job Open Source Alternatives to PDI;ETL<br>Optimizations. | 12 |
| UNIT – 4 | **BUSINESS REPORTING, AND PERFORMANCE MANAGEMENT**<br>**Business Reporting**: Business Reporting Definitions and Concepts, Data and Information Visualization, Different Types of Charts and Graphs, The Emergence of Data Visualization and Visual Analytics, BI Tools: Microstrategy Desktop-Tableau, Microsoft Power BI, Qlik Sense.<br>**Performance Management:** Performance Dashboards, Closed-Loop BPM Cycle, Performance Measurement, Key Performance Indicator, Balanced Scorecards, Six Sigma as a Performance Measurement System. | 12 |
| UNIT – 5 | **MOVING BI PROCESS TO PRODUCT ENVIRONMENT** | 12 |

| | | |
|---|---|---|
| | Multi environment Scenario-Deploying a Productive Environment, Adding Environments, Isolation of Environments, Multi environment Recommendations; Maintaining Your Environment, Security, Auditing, Moving BI Processes to the Cloud- Deciding our Cloud Provider, Choosing the Right Cloud Provider: Amazon Web Services (AWS), Microsoft Azure, Google Cloud, Vendor-Based Cloud Solutions. | |
| | **Total** | 60 |

**Text Books:**

1. Albert Nogus, Juan Valladaraes, Business Intelligence Tools for Small Companies, Apress, Tenth Edition 2017.
2. ChandraishSinha, Mastering PowerBI, BpB Publications,2022.

**Reference Books:**

1. Ramesh Sharda, DursunDelen, Efraim Turban, Business Intelligence and Analytics, Pearson, 10th Edition,2014.
2. Hancoc,;Toren, Practical Business Intelligence with SQL Server 2005, Pearson,2022.

| II Semester | DATA ENGINEERING | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**

The objectives of this course are to

1. Understand the core concepts and capabilities of modern data engineering, including cloud computing, data lakes, and data storytelling.
2. Explore the structure and architecture of data lakes and data pipelines, focusing on storage, compute resources, and compliance frameworks.
3. Learn how to create and implement data curation pipelines, understand Delta Lake, and perform data transformations.
4. Develop data aggregation pipelines, understand the gold layer, and ensure data verification and proper data consumption.
5. Address the challenges in data engineering, including deployment, monitoring, and managing data pipelines in production environments.

**Course Outcomes**: On completion of this course, the student will be able to:

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Understand the core capabilities of data storage and compute resources, the role of cloud computing in data engineering, and how data storytelling influences decision making. | K2 |
| **CO2** | Design and implement data lakes, segregate storage and compute, and adhere to compliance frameworks while understanding the CAP theorem. | K3 |
| **CO3** | Build and run data pipelines, understand different data collection stages, and design ingestion pipelines for raw data collection. | K3 |
| **CO4** | Implement data curation pipelines, utilize Delta Lake for time travel and upserts, and curate raw data into a usable silver layer. | K3 |
| **CO5** | Aggregate data effectively, build and run aggregation pipelines, verify aggregated data in the gold layer, and monitor and deploy pipelines in production environments. | K4 |

#Based on suggested Revised BTL

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | H | L | M | M | L |
| **CO2** | H | M | H | M | M | M |
| **CO3** | M | M | H | M | M | L |
| **CO4** | M | M | H | H | M | M |
| **CO5** | H | M | H | M | H | H |

(Please fill the above with Levels of Correlation, viz., L, M, H)

| UNIT | CONTENTS | Contact Hours |
|---|---|---|
| UNIT – 1 | **MODERN DATA ENGINEERING AND TOOLS**<br>Data Engineering and Analytics: Core capabilities of storage and compute resources, Availability of varying datasets, Computing Adoption of cloud computing, Data storytelling, The monetary power of data.<br>Discovering Storage and Compute Data Lakes: Exploring the benefits of data lakes, Adhering to compliance frameworks, Segregating storage and compute in a data lake, Discovering data lake Architectures, The CAP theorem. | 12 |
| UNIT – 2 | **DATA PIPELINES AND DATA COLLECTION STAGE**<br>Understanding Data Pipelines: Components of a data pipeline, Process of creating a data pipeline, Running a data pipeline<br>Data Collection Stage: Architecting the Electroniz data lake, Understanding the bronze layer, Configuring data sources, Configuring data destinations, Building the ingestion pipelines. | 12 |
| UNIT – 3 | **DATA CURATION STAGE**<br>Understanding Delta Lake: Understanding Delta Lake, Creating a Delta Lake table, Changing data in an existing Delta Lake table, Performing time travel, Performingupserts of data, Understanding isolation levels, Understanding concurrency control.<br>Data Curation Stage: The need for curating raw data, The process of curating raw data, Developing a data curation pipeline, Running the pipeline for the silver layer, Verifying curated data in the silver layer. | 12 |
| UNIT – 4 | **DATA AGGREGATION STAGE**<br>The need to aggregate data, The process of aggregating data, Developing a data aggregation pipeline, Running the aggregation pipeline, Understanding data consumption, Verifying aggregated data in the gold layer. | 12 |
| UNIT – 5 | **DATA ENGINEERING CHALLENGES AND EFFECTIVE DEPLOYMENT STRATEGIES**<br>Deploying and Monitoring Pipelines in Production: The deployment strategy, Developing the master pipeline, Testing the master pipeline, Scheduling the master pipeline, Monitoring pipelines.<br>Solving Data Engineering Challenges: Schema evolution, Sharing data, Data governance. | 12 |
| | **Total** | 60 |

**Text Books:**

1. ManojKukreja, DanilZburivsky, Data Engineering with Apache Spark, Delta Lake, and Lakehouse: Create Scalable Pipelines that Ingest, Curate, and Aggregate Complex Data in a Timely and Secure Way, Packt Publishing, 2021.
2. Crickard, Paul, Data Engineering with Python: Work with Massive Datasets to Design Data Models and Automate Data Pipelines Using Python, Packt Publishing, 2020.

**Reference Books:**

1. Eagar, G, Data Engineering with AWS: Learn how to Design and Build Cloud-based Data Transformation Pipelines Using AWS, Packt Publishing, 2021.
2. Housley, Matt, and Reis, Joe, Fundamentals of Data Engineering: Plan and Build Robust Data Systems, O'Reilly Media, Incorporated, 2022.

| II Semester | DEEP LEARNING LAB | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 2 |

**Course Objectives:**

The main objective of this course is to

1. Learn how to implement and optimize basic machine learning models like gradient descent and neural networks from scratch to minimize a cost function.
2. Gain practical experience in building and training Convolutional Neural Networks (CNNs) for image classification and Recurrent Neural Networks (RNNs) for sequential data analysis.
3. Learn how to use pre-trained models and fine-tune them for new tasks, and understand how advanced deep learning architectures (like GANs and GNNs) work.
4. Implement deep learning solutions for tasks such as sentiment analysis, stock price prediction, and language detection, applying data augmentation and advanced techniques for improving model performance.

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

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Implement basic machine learning algorithms, including gradient descent and neural network optimization, from scratch to minimize cost functions. | K3 |
| **CO2** | Build and train Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) using TensorFlow and PyTorch for image classification and sequential data prediction tasks. | K3 |
| **CO3** | Apply transfer learning with pre-trained models such as VGG16, ResNet, and MobileNet to solve image classification problems. | K4 |
| **CO4** | Develop Generative Adversarial Networks (GANs) to generate synthetic data and solve image generation tasks. | K5 |
| **CO5** | Solve real-world problems in NLP (Sentiment Analysis), time-series forecasting (Stock Prediction), and language detection using neural networks and advanced deep learning techniques. | K3 |

*#Based on suggested Revised BTL*

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | H | M | L | L | L |
| **CO2** | H | M | M | H | M | M |
| **CO3** | M | M | H | M | M | M |
| **CO4** | M | H | L | H | L | L |
| **CO5** | M | M | H | H | H | H |

| Experiments | CONTENTS |
|---|---|
| **Week 1** | **Implementing Gradient Descent Algorithm from Scratch**<br>**Objective:** Understand and implement the gradient descent optimization algorithm to minimize a simple cost function. |
| **Week– 2** | **Data Preprocessing**<br>**Objective:** Load, reshape, normalize, and preprocess data for a neural network model. This includes converting labels to one-hot encoding |
| **Week– 3** | **Building and Training Neural Networks using Tensorflow**<br>**Objective:** Build, train, validate, and infer with a neural network using Keras, and learn to save and reload the model |
| **Week– 4** | **Building and Training Neural Networks using PyTorch**<br>**Objective:** Build, train, validate, and infer with a neural network using PyTorch, and learn to save and reload the model |
| **Week– 5** | **Binary Classification of Images**<br>**Objective:** Create a CNN that can differentiate between cat and dog images.<br>**Dataset:** Cats vs. Dogs Dataset (commonly found on Kaggle) |
| Week-6 | **Multiclass Classification of Images**<br>**Objective:** Build a simple convolutional neural network (CNN) to classify images Datasets: MNIST, Fashion-MNIST and CIFAR-10 |
| **Week 7** | **Implementing Data Augmentation**<br>**Objective:** Apply data augmentation techniques to enhance the training dataset for a neural network, improving model robustness and helping prevent overfitting. |
| **Week– 8** | **Transfer Learning for Image Classification**<br>**Objective:** Utilize a pre-trained model (like VGG16, ResNet, or MobileNet) as a feature extractor and fine-tune it to classify a new set of images.<br>**Dataset:** Use the Oxford 102 Flowers dataset for flower classification or the Stanford Cars dataset for car classification. |
| **Week– 9** | **Sentiment Analysis**<br>**Objective:** Train a neural network to classify movie reviews from the IMDB dataset as positive or negative.<br>**Dataset:** IMDB Movie Reviews |
| **Week– 10** | **Stock Prices Prediction**<br>**Objective:** Build a model using RNNs to predict future stock prices based on historical price data.<br>**Dataset:** Any stock price historical data |
| **Week– 11** | **Language Detection**<br>**Objective:** Train a neural network to detect the language of a given text snippet.<br>**Dataset:** WiLI-2018, a benchmark dataset for language identification |

| | |
|---|---|
| **Week-12** | **Generative Adversarial Network (GAN)**<br>**Objective:** Generate digits by training a GAN on Identify the Digits (MNIST) dataset |
| **Week-13** | **Graph Neural Network (GNN)**<br>**Objective:** Implement and explore basic Graph Neural Network (GNN) architectures to solve problems related to molecular data<br>**Dataset:** Molecule Net (Tox-21) |

**Text Books:**

1. Chollet, François. "Deep Learning with Python, " Manning Publications, 2017.

**Reference Books:**

1. Deep Learning by Ian Goodfellow, YoshuaBengio and Aaron Courville, MIT Press.
2. The Elements of Statistical Learning by T. Hastie, R. Tibshirani, J. Friedman, Springer.
3. Probabilistic Graphical Models. Koller, N. Friedman, MIT Press.

| II Semester | DATA VISUALIZATION LAB | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 2 |

**Course Objectives:**

The objectives of this course are to

1. Understanding Data Visualization Techniques: Equip students with the skills to use various R packages for visualizing datasets, including histograms, scatter plots, and heat maps.
2. Exploring Data Structures in R: Introduce students to the structure of various datasets (e.g., VADeaths, AirQuality, Iris, Diamonds) and how to manipulate them in R for effective visualization.
3. Advanced Visualizations: Enable students to generate advanced visualizations such as 3D graphs, correlograms, and maps to present multidimensional data.
4. Hands-On Practice with R Libraries: Familiarize students with R libraries such as ggplot2, leaflet, maps, and hexbin for data visualization, along with installation, manipulation, and visualization of large datasets.

**Course Outcomes**: On completion of this course, the student will be able to:

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | Demonstrate the ability to load, explore, and visualize datasets using basic charts such as histograms, bar charts, and line charts. | K2 |
| **CO2** | Analyze and visualize multidimensional data using advanced visualization techniques such as scatter plots, box plots, and hexbin plots in R. | K3 |
| **CO3** | Implement and visualize correlation matrices and perform data aggregation using advanced tools such as correlogram and heatmap. | K3 |
| **CO4** | Utilize interactive data visualizations through R libraries like leaflet and maps to represent geographical and spatial data effectively. | K4 |
| **CO5** | Develop proficiency in handling large datasets, such as the Diamonds dataset, and visualizing categorical and continuous data through complex visualizations. | K4 |

#Based on suggested Revised BTL

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | M | H | M | H | L | M |
| **CO2** | M | H | M | H | M | M |
| **CO3** | M | M | M | H | M | L |
| **CO4** | L | M | L | H | M | M |
| **CO5** | M | M | H | M | H | M |

(Please fill the above with Levels of Correlation, viz., L, M, H)

| SNO | **List of Experiments** |
|---|---|
| **1** | a) Load VADeaths(Death Rates in Virginia)dataset in R and visualize the data using different histograms.<br>b) Load air quality dataset in R and visualize La Guardia Airport's dialy maximum temperature using histogram. |
| **2** | Load AirPassengers dataset in R and visualize the data using line chart that shows increase in air passengers over given time period. |
| **3** | a) Load iris dataset in R, visualize the data using different Bar Charts and also demonstrate the use of stacked plots.<br>b) Load air quality dataset in R and visualize ozone concentration in air. |
| **4** | a) Load iris dataset in R, visualize the data using different Box plots including group by option and also use color palette to represent species.<br>b) Load air quality dataset in R and visualize air quality parameters using box plots. |
| **5** | Visualize iris dataset using simple scatter, multivariate scatter plot and also visualize scatter plot matrix to visualize multiple variables across each other. |
| **6** | Load diamonds dataset in R and visualize the structure in datasets with large data points using hexagon binning and also add color palette then use the |
| **7** | Load HairEyeColor dataset in R and plot categorical data using mosaic plot. |
| **8** | Load mtcars dataset in R and visualize data using heat map. |
| **9** | Install leaflet library in R and perform different map visualizations. |
| **10** | Visualize iris dataset using 3d graphs such as scatter3d, cloud, xyplot. |
| **11** | Make use of correlogram to visualize data in correlation matrices for iris dataset. |
| **12** | Install maps library in R and draw different map visualizations. |

**Web References:**

1. https://www.analyticsvidhya.com/blog/2015/07/guide-data-visualization-r/
2. https://www.geeksforgeeks.org/data-visualization-in-r/

| III Semester | RESEARCH METHODOLOGY AND IPR | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 3 |

**Course Objectives:**

1. Students will be able to define what constitutes a research problem by identifying gaps, inconsistencies, or limitations in existing knowledge.
2. Students will conduct comprehensive literature reviews to pinpoint unresolved issues or future research directions, synthesizing information to formulate clear research questions.
3. Students will demonstrate the ability to convert broad topics or practical concerns into focused, manageable, and empirically investigable research problems

**Course Outcomes**: At the end of the course, student will be able to (Four to Six )

| | | Knowledge Level (K)# |
|---|---|---|
| **CO1** | *Identify and formulate research problems, design investigative approaches, and apply appropriate data collection and analysis methods.* | K2 |
| **CO2** | *Conduct effective literature reviews, maintain research ethics, and prepare structured technical reports and research proposals.* | K3 |
| **CO3** | *Explain the nature and types of Intellectual Property Rights and processes for patenting innovations nationally and internationally.* | K2 |
| **CO4** | *Analyze patent rights, licensing processes, technology transfer, and the use of patent databases.* | K4 |
| **CO5** | *Evaluate recent developments in IPR, including biological systems, software, and traditional knowledge through case studies.* | K5 |

*#Based on suggested Revised BTL*

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 |
|---|---|---|---|---|---|---|
| **CO1** | H | | M | | | |
| **CO2** | | H | | | | |
| **CO3** | | | M | | | M |
| **CO4** | | | M | | | M |
| **CO5** | | | M | | | M |
| **CO6** | | | | | | |

**(Please fill the above with Levels of Correlation, viz., L, M, H)**

| UNIT | CONTENTS | **Contact Hours** |
|---|---|---|
| **UNIT – 1** | Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. | 12 |

| | | |
|---|---|---|
| | Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations | |
| **UNIT – 2** | Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee | 12 |
| **UNIT – 3** | Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT | 12 |
| **UNIT – 4** | Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. | 12 |
| **UNIT – 5** | New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs | 12 |
| | **Total** | 60 |

**REFERENCES:**

(1) Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
(2) Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
(3) Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
(4) Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
(5) Mayall, "Industrial Design", McGraw Hill, 1992.
(6) Niebel, "Product Design", McGraw Hill, 1974.
(7) Asimov, "Introduction to Design", Prentice Hall, 1962.
(8) Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in NewTechnological Age", 2016.T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.