M. Tech. Computer Science and Engineering

Under Regulations- (R-2025)

(w.e.f. 2025-26 admitted batch)

Course Structure and Syllabi

THE APOLLO UNIVERSITY

MURUKAMBATTU - CHITTOOR (Dt) 517127

ANDHRA PRADESH

PROGRAM OUTCOMES (PO)

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation for the solution of complex engineering problems.

PO 2: Problem analysis: Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3: Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.

PO 4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO 6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and the need for sustainable development.

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long learning: Recognise the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM EDUCATIONAL OBJECTIVES (PEO):

PEO1: Advanced Knowledge Application: Graduates will demonstrate advanced knowledge in computer science theories, algorithms, and practices to solve complex real-world problems in various industries such as software development, research, and systems engineering.

PEO2: Leadership and Innovation: Graduates will exhibit leadership qualities and the ability to work collaboratively in interdisciplinary teams, fostering innovation in emerging technologies like AI, machine learning, data science, and cybersecurity.

PEO3: Ethical and Societal Responsibility: Graduates will approach computing challenges with ethical considerations and contribute to the societal good by creating technologies that are secure, inclusive, and environmentally sustainable.

PROGRAM SPECIFIC OUTCOMES (PSO):

After successful completion of the program the graduates will be able to:

PSO 1: Software Development Proficiency: Graduates will possess the ability to design, develop, and deploy sophisticated software solutions, leveraging state-of-the-art development tools, methodologies, and technologies.

PSO2: Research and Analytical Skills: Graduates will be able to conduct independent research, critically evaluate existing technologies, and contribute to the advancement of the field through innovative problem-solving techniques and technical publications.

PSO3: System Design and Optimization: Graduates will be skilled in the design, optimization, and evaluation of computer systems, with an emphasis on high performance, scalability, and security, ensuring that they meet both functional and non-functional requirements in diverse contexts.

THE APOLLO UNIVERSITY

ACADEMIC REGULATIONS

SCOPE:

This Academic regulation provide a framework for the regulatory guidelines of all programs offered by The Apollo University. It includes procedures and practices that are to be followed to ensure academic standards in the University. The regulations are approved by the Academic Council. These regulations may be amended from time to time with the approval of the Academic council for the benefit of students or some times to reflect the changes suggested by the statutory bodies.

Information regarding amendments (if any) to the regulations will be communicated to the students by publishing in the University website. Students must follow the amended regulations as they might impact the process for the award of degree. The decision of the Vice Chancellor shall be the final in case of any discrepancy. These regulations apply to all students, despite the program of study.

1. ADMISSION INTO THE PROGRAM

The University admits the students in two modes. One through the convenor quota as per the Andhra Pradesh Private Universities Act, for which the admissions will be carried out through the convener quota by the Govt of Andhra Pradesh. The other is through University quota for which the following procedure will be followed:

A. The applicant shall satisfy the entrance requirements specified by The Apollo University and in accordance with guidelines of statutory councils for Under-graduation.
B. The Applicant shall be qualified in the qualifying examination for a particular program.
C. The Applicant secures a rank in national level entrance exam or suitable such test conducted by The Apollo University / professional body.
D. The Applicant qualifies in the specified state or national level examinations prescribed by The Apollo University.

The Apollo University will widely notify the counselling schedule for admissions into the academic programs in the media. The provisional admission will be given to the eligible students during the counseling scheduled by The Apollo University. The selected candidates will be provisionally admitted into the program of his/her choice if the candidate meets

the program specific requirements in addition to academic performance qualifying exam. Admission is purely based on merit and so merely meeting the requirements will not ensure admission. The University does not discriminate based on gender, race, region, religion, disability or nationality. The University reserves the right to make admissions based on various criteria which is specified in the admission brochure.

2. ELIGIBILITY CRITERIA

Undergraduate programs

The qualifying exam eligibility for each program is given Annexure 1. The student should have passed the qualifying exam either in the year the student is seeking admission or the previous year.

Convener Quota: The student seeking admission to any program under convener quota shall qualify in the relevant entrance exam conducted by the Government of Andhra Pradesh.

University Quota: For getting admission under University quota, percentage of marks obtained in the qualifying exam, the rank obtained in TAU entrance exam or any recognized national level examination in the year of admission will be considered.

Counselling

All the eligible students need to apply for admission and have to attend counselling conducted by TAU as per the schedule for the university quo

3. PROGRAMS

The Apollo University offers variety of programs which includes certificate, undergraduate, postgraduate, and Research. The list of programs on offer for the academic year 2022-23 are annexed in Annexure 2 and those of 2023-24 are annexed in Annexure 3.

Minimum duration of the program

The minimum duration of each program depends on the type of program, viz., undergraduate, postgraduate, integrated programs, etc., and the faculty which offers the program. The maximum duration of the program is N+2 years, where N stands for the minimum duration of the program as mentioned in Annexure 2 and 3. If the student has not obtained the minimum number of credits within the stipulated time, the Vice-Chancellor may extend the maximum duration in extenuating circumstances upon receiving a request along with reasons from the student for not completing the program on time.

4. CHOICE BASED CREDIT SYSTEM

The choice-based credit system (CBCS) facilitates the education student-centric. It provides the opportunity for the learner to choose the courses from a basket of core, elective, and skill enhanced courses. All programs of study are designed to meet the specified number of credit requirements. The courses taken by the student in each semester as part of program are allotted some credit points based on the number of hours assigned. Upon successful completion of the course, the student secures the number of credits allotted for that course. Once the minimum number of credits of the program is achieved, the degree can be awarded, subject to fulfilment of all other relevant conditions.

5. STRUCTURE OF THE PROGRAM

The Program structure Consists of

i) University Courses
   A. University Core
   B. University Electives
ii) Faculty Courses
   A. Faculty Core
   B. Faculty Electives
iii) Program Courses
   A. Program Core
   B. Program electives

Each course* is assigned a certain number of credits depending upon the number of contact hours (lectures/tutorials/practical) per week. (*one course means one subject)

Core Courses = 3 Credits /4 Credits Elective =3 Credits

In general, credits are assigned to the courses as detailed below:

- A classroom lecture/ tutorial of 60 min (1 hr) duration per week, spread over the entire semester, shall be considered as one credit.
- A laboratory session of minimum of 120 min (2 hr) per week shall be considered as one credit.
- A project work/ Internship session of 60 minutes (1 hr) carried out per week shall be considered as one credit.

6. MEDIUM OF INSTRUCTION

The medium of instruction (including examinations and project reports) shall be English.

7. REGISTRATION

Any of the following students must register for the courses opted in a particular semester during the scheduled registration period.

i. a new student who enrolls into any program
ii. an existing student who is continuing on rolls from the preceding regular semester
iii. a former student, i.e., who has not enrolled in the preceding regular semester or who has availed academic break or detained and got readmission

Each newly admitted student shall attend an induction/ orientation program prior to commencement of the first semester. During this program academic advisors assist the students in choosing the courses. Existing student may register online by using their registration number and mail ID through the Apollo ERP portal. Class schedules are available approximately two weeks before the beginning of every semester for each program. The concerned head of the department must approve class schedule.

8. ATTENDANCE REQUIREMENTS

- Students should earn a minimum of 80% attendance in the current semester to become eligible to write the Semester End Examinations.
- The monthly statement of attendance will be displayed on the Department Notice Board/ Apollo ERP by the respective departments within the first five working days of the following month.
- Candidates who are falling short of 80% attendance will be detained on the recommendation of the HoD and are not eligible to appear for the current semester examinations. The students who are detained in the current semester will not be allowed to register for the next semester and they have to repeat the same semester by paying the tuition fee prescribed. However, they can write arrear subjects, if any.

9. EVALUATION

The assessment of the student's performance in a Theory course shall be based on two components: Continuous Evaluation (40 marks) and Semester-end examination (60 marks). A student has to secure an aggregate of 40% in the course in the two components put together to be declared to have passed the course, subject to the condition that the candidate must have secured a minimum of 24 marks (i.e. 40%) in the theory component at the semester-end

examination. Practical/ Project Work/ Industrial Training/ Viva voce/ Seminar etc. are completely assessed under Continuous Evaluation for a maximum of 100 marks, and a student has to obtain a minimum of 50% to secure Pass Grade. For courses having both theory and practical components, 60% of the weightage will be given for theory component and 40% weightage for practical component. The student must secure 40% (Theory + Practical) with 24 marks minimum in theory to attain pass grade.

Details of Assessment Procedure are furnished below in Table 1.

Table 1: Assessment Procedure

S. No.	**Component of Assessment**	**Marks Allotted**	**Type of Assessment**	**Scheme of Evaluation**
1	Theory	40	Continuous Evaluation	i) Twenty (20) marks for mid examinations. Three mid examinations shall be conducted for 20 marks each; average of the best two performances shall be taken into consideration. ii) Ten (10) marks for Quizzes, Assignments and Presentations. iii) Ten (10) marks for periodic evaluation, case studies and projects
		60	Semester-end Examination	iv) Sixty (60) marks for Semester-end examinations
	Total	**100**		

2	Laboratory	100	Continuous Evaluation	1)80 marks with equal weightage to all experiments subject to conduct of minimum of 10 experiments 2)20marks for the end exam (with one of our university teachers as external other than course teacher)
3	Internship	100	Continuous Evaluation	i) (80) marks for periodic evaluation of Internship report by the Project Supervisor. ii) Twenty (20) marks for final Report presentation and Viva-voce, by a panel of internal examiners. iii) Students shall undergo TWO internships during the course of time and the evaluation shall be done during final semester.
4	Project work	100	Continuous Evaluation	iv) (80) marks for periodic evaluation and technical report writing by the Project Supervisor. ii) Twenty (20) marks for final Report presentation and Viva-voce, by a panel of internal examiners

5	Students Seminars	100	Continuous Evaluation	Each student has to give a seminar on any topic in consultation with the faculty member in charge A detailed report shall be submitted to the in charge. 60 marks for periodic evaluation including report preparation and 40 marks for viva voce by a panel of examiners.

GRADING SYSTEM

Based on the student performance during a given semester, a final letter grade will be awarded at the end of the semester in each course. The letter grades and the corresponding grade points are as given inTable2.

Table 2: Grades & Grade Points

Sl. No.	Grade	Grade Points	Absolute Marks
1	O(Outstanding)	10	90 and above
2	A+(Excellent)	9	80 to 89
3	A (Very Good)	8	70 to 79
4	B+(Good)	7	60 to 69
5	B (Above Average)	6	50 to 59
6	C(Average)	5	45 to 49
7	P(Pass)	4	40 to 44
8	F(Fail)	0	Less than 40
9	Ab. (Absent)	0	-

SEMESTER GRADEPOINTAVERAGE (SGPA)

A Semester Grade Point Average (SGPA) for the semester will be calculated according to the formula:

$$SGPA \frac{\sum[CXG]}{\sum C}$$

Where

C=number of credits for the course,

G=grade points obtained by the student in the course.

A student who earns a minimum of 4 grade points (P grade) in a course is declared to have successfully completed the course, and is deemed to have earned the credits assigned to that course.

CUMULATIVE GRADE POINT AVEARGE (CGPA)

A similar formula is used to arrive at Cumulative Grade Point Average (CGPA), considering the student's performance in all the courses taken in all the semesters up to the particular point of time.

Table 3 shows the CGPA required for the award of class after the successful completion of the program.

Table3: CGPA required for award of Class

Class	**CGPA Required**
First Class with Distinction	≥8.0*
First Class	≥6.5
Second Class	≥5.5
Pass Class	≥5.0

*In addition to the required CGPA of 8.0 or more, the student must have necessarily passed all the courses of every semester in first attempt.

11. REAPPEARANCE

a. A student who has secured 'F' grade in a Theory course shall have to reappear at the subsequent Semester end examination held for that course.
b. A student who has secured 'F' grade in a Practical course shall have to attend

Special Instruction Classes scheduled by the Department for securing pass.

c. A student who has secured 'F' Grade in Internship /Project work / Industrial Training etc shall have to reappear for Viva – voce scheduled by the department.
d. A student who is declared fail (F) in a course/s can apply for revaluation within one week from the date of publication of results with a fee prescribed by the university. The marks /grade awarded in the revaluation is final.

11.1 Procedure for revaluation

- The students who have not satisfied with the marks awarded by the examiner can apply for revaluation of his/her answer script/s
- The students have to apply through proper channel for revaluation and to pay the revaluation fee per paper to the university towards revaluation fee.
- Students have to apply for revaluation within 7 days from the date publication of result.
- The scripts will get valued by second examiner and if the difference is more than 15 marks, they will get valued by the third examiner. The average of the nearest two marks will be declared as the final marks.

11.2 ASSESSMENT MECHANISM

The Apollo University offers a student the benefits of Choice Based Credit System. Every paper is allotted a certain number of credits as per the UGC norms. A student is awarded the specified credits on obtaining a pass in the respective paper.

The Choice Based Credit System (CBCS) has been adopted for UG Course from the year 2021-22 onwards as per the recommendations of the A.P. State Council for Higher Education (APSCHE). The structure of undergraduate programmes provides a wide range of choice for students to opt for courses based on their eligibility, aptitude and career goals.

11.3 Semester End Examination

The End semester examination will be a comprehensive examination of 3 hours duration. Two End Semester examinations are conducted in a year-

Odd semester examinations in November/ December and

Even semester examination in May/June

Practical examination / Project viva to be held before 2 weeks prior to the theory semester end examinations.

PG-Graduation Programs

Course	Continuous Assessment	End semester	Aggregate in End semester Examinations
All PG Courses	No passing minimum	50%	50%

11.4 Post Evaluation Programme:

Under the Post Evaluation Programme there are three menus:

- Provision for improvement
- Re-totaling and Revaluation of answer scripts
- Restrictions to appear for the examinations

11.5 Provision for improvement

A student who passes a paper in the first attempt can reappear for the same paper in the succeeding End-of-Semester examination only, for improving his/her marks. Re-appearance for improvement is allowed for theory and practical subjects of all semesters, except for the final semester subjects. Revised mark statement will be issued after withdrawing the previous one, if the marks obtained in improvement are higher than the marks awarded earlier. When there is no improvement, there shall not be any change in the original marks already awarded. The improved marks shall be considered for classification but not for ranking.

Provision for Re-totaling and Revaluation of valued answer scripts

- PG candidates may apply for re-totaling / revaluation of valued answer scripts, to the Controller of Examinations through the Heads of Departments and Principal / Dean, in the prescribed forms, remitting the prescribed fee within 7 days from the date of publication of results. Revaluation of answer scripts is permissible only for the current semester papers and not for any arrear paper.
- Those wish to apply for revaluation of final semester papers can do so within five days from the date of publication of results. In re-valuation, the answer papers will be valued by an external examiner and if there is a difference of 15 marks between the two evaluations then the script will be sent for third valuation

which is final and the mark awarded by the third examiner will be taken into the account.

- Revised mark statement will be issued after withdrawing the previous one, if the marks obtained in revaluation / retotalling are higher than the marks obtained earlier. In other cases, the original marks obtained earlier will be retained and the matter will be intimated to the student concerned as 'No change'.
- A candidate who applies for revaluation should not apply for retotalling.

Restrictions to appear for the examinations

Candidates who fail in any of the papers in the PG End semester examinations shall complete the paper concerned within N+2 years from the date of admission to the particular course. If they fail to do so, they shall re-register their names and take the examination in the texts/revised regulations/syllabus of the paper prescribed for the subsequent batch of candidates, in force at the time of their reappearance. In the event of removal of that paper consequent to change of regulation and/or curriculum after N+2 years period, the candidate shall have to take up an equivalent paper in the revised syllabus as suggested by the Chairman, Board of Studies concerned.

12. BETTERMENT OF GRADES

A student who has secured only a Pass or Second class and desires to improve his/her Class can appear for Betterment Examinations only in Theory courses of any Semester of his/her choice, conducted in Summer Vacation along with the Special Examinations. Betterment of Grades is permitted 'only once' immediately after completion of the program of study.

13. DETENTION AND RE-ADMISSION

If a student fails to meet the minimum attendance requirement or minimum standards for academic progression, the concerned academic head will recommend for detention and it will be notified by the concerned Dean of the School. The students who are detained in the current semester will not be allowed to register for the next semester and they have to repeat the same semester.

The candidates who are detained or availed academic break or suspended in the previous semester/academic year and want to continue their study shall apply for re-admission to the university. The candidates shall request for re-admission to the respective Head of the

Department, with details viz., Full Name, Registration Number, Department, School, Fee payment particulars with proofs and reasons for discontinuations. The concerned academic head will forward it to the Registrar with specific comments. The Registrar will notify the decision of re-admission which shall include the prescribed fee particulars, semester/ year into which readmission is granted and additional courses to be completed by the student (if any). The candidates should apply for re-admission in advance, that is before the commencement of the semester.

14. GROOMING AND ATTIRE FOR STUDENTS

Grooming and Etiquette is of great significance in the dynamic of shaping one's Personality. The Apollo University stands by a *Code of Grooming, Attire and Etiquette* that promotes a professional standard: Academic Day; Campus Placements and Non-Academic Hours on Campus.

The Dress Code to be in compliance on academic premises while attending: Formal Functions of the Institution / Lectures / Practicals / Dining Area / Library / Labs / Office Areas.

Students shall follow appropriate attire during Academic and Non-Academic hours on the campus. Students shall wear clean, neat, pressed and presentable clothing, and command respect by dressing in accordance with responsible personal norms. Students shall always wear The Apollo University ID Card with the Lanyard.

Grooming and Formal Wear - Boys:

Formal Shirts / T-Shirts with a Collar should preferably be tucked in with a Formal pair of Pants Shoes and Socks to complete the Formal Attire. Personal Hygiene should be followed and Hair should be well groomed.

Smart Casuals for Boys:

Long Kurtas / Formals / Semi-Formal Shirts with Jeans.

Grooming and Formal Wear - Girls: Sarees / Salwar Suits / Leggings or Jeggings with Long Kurtis / Long Frocks / Long Skirts / Palazzos. Complement the outfit with proper footwear. Personal Hygiene should be followed and Hair should be well groomed.

Smart Casuals for Girls:

Jeans with long Kurtis / Long Skirts / Long Frocks.

Attire for Non-Academic Hours On Campus:

The students should be neatly attired during Non-Academic Hours on Campus.

Dress Code for Boys:

Jeans / Track Suits / T-Shirts / Trousers / Shirts.

Dress Code for Girls:

Jeans / T-Shirts or Blouses / Salwar Suits / Palazzos / Leggings or Jeggings with Long Tops / Sarees / Long Skirts / Track Suits.

DO'S AND DO'NTS FOR BOYS AND GIRL STUDENTS OF THE UNIVERSITY:

- To wear modest clothing that reflects the essence of good personal grooming standards.
- To refrain from wearing Sleeveless Clothing; Shorts; Short Tops, etc.,

PLEASE NOTE: The decision as to what constitutes Appropriate Attire vests with the Authorities of The Apollo University.

15. ELIGIBILITY FOR AWARD OF THE DEGREE

The Post degree will be of 2 of duration. A student shall be declared as eligible for the award of the degree if the candidate has successfully secured the minimum number of required credits as specified in the curriculum corresponding to the branch of his/her study within the stipulated time.

After successful completion of the program, a provisional certificate cum memorandum of grades (PCMG) will be issued to the students. The PCMG includes the secured grades and class achieved in chosen program and specialization if any, along with grades and CGPA secured by the student. The original degree will be presented in the subsequent convocation.

16. DISCRETION POWER

Not with-standing anything contained in the above sections, the Vice Chancellor may review all exceptional cases, and give his decision, which will be final and binding.

ANNEXURE 1

ELIGIBILITY FOR QUALIFYING EXAM FOR POST GRADUATE PROGRAM

Program Type	**Program Name**	**Eligibility**
Masters	**M.Tech. Computer Science and Engineering**	Pass with 50% aggregate marks (45% for reserved categories) in B.Tech. (Computer Science and Engineering or Information Technology or Electronics and Communication Engineering or Electrical and Electronics Engineering) or MCA or M.Sc. (Information Technology or Computer Science) or equivalent.

ANNEXURE 2

PROGRAMS OFFERED BY THE SCHOOL OF TECHNOLOGY

FROM ACADEMIC YEAR 2022-23

Sl. No.	Program	Expanded	Level	Minimum Duration in Years (N)
1	B. Tech. CSE	Computer Science and Engineering	Bachelor's	4*
2.	B. Tech. CSE (AI& DS)	Computer Science and Engineering (Artificial Intelligence and Data Structures)	Bachelor's	4*

* Engineering programs (UG) under Lateral Entry will be with a minimum duration of 3 years

ANNEXURE 3

PROGRAMS OFFERED BY THE SCHOOL OF TECHNOLOGY

FROM ACADEMIC YEAR 2023-24

Sl. No.	Program	Expanded	Level	Minimum Duration in Years (N)
1	B. Tech. CSE	Computer Science and Engineering	Bachelor's	4
2.	B. Tech. CSE (AI& DS)	Computer Science and Engineering (Artificial Intelligence and Data Structures)	Bachelor's	4
3	B. Tech. CSE (AI& ML)	Computer Science and Engineering (Artificial Intelligence and Machine Learning)	Bachelor's	4
4	B. Tech CSE (Cybersecurity)	Computer Science and Engineering (Cybersecurity)	Bachelor's	4
5	B.Tech Computer Engineering (Software Engineering)	Computer Engineering (Software Engineering) with Kalium	Bachelor's	4
6	M. Tech (VLSI design & ES)	Master of Technology in Very Large-Scale Integration design and Embedded Systems	Masters	2

* Engineering programs (UG) under Lateral Entry will be with the Minimum duration of 3 years

ANNEXURE 3

PROGRAMS OFFERED BY THE SCHOOL OF TECHNOLOGY

FROM ACADEMIC YEAR 2024-25

Sl. No.	Program	Expanded	Level	Minimum Duration in Years (N)
1	B. Tech. CSE	Computer Science and Engineering	Bachelor's	4
2.	B. Tech. CSE (AI& DS)	Computer Science and Engineering (Artificial Intelligence and Data Structures)	Bachelor's	4
3	B. Tech. CSE (AI& ML)	Computer Science and Engineering (Artificial Intelligence and Machine Learning)	Bachelor's	4
4	B. Tech CSE (Cybersecurity)	Computer Science and Engineering (Cybersecurity)	Bachelor's	4
5	B.Tech Computer Engineering (Software Engineering)	Computer Engineering (Software Engineering) with Kalium	Bachelor's	4
6	M. Tech (VLSI design & ES)	Master of Technology in Very Large-Scale Integration design and Embedded Systems	Masters	2

* Engineering programs (UG) under Lateral Entry will be with the Minimum duration of 3 years

I – Semester

3 Week Induction Program						
Course Code	**Course Name**	**Periods per week**			**Credits**	**Hours per week**
		L	**T**	**P**		
MTCT6501	Mathematical Foundations of Computer Science	2	1	0	3	3
SOTT6301	Advanced Data Structures and Algorithms	2	1	0	3	3
Program Elective – I						
MTCT6601a	Deep Learning	3	0	0	3	3
MTCT6601b	Natural Language Processing					
MTCT6601c	Generative AI					
Program Elective – II						
MTCT6602a	Enterprise Cloud Concepts	3	0	0	3	3
MTCT6602b	Data Science					
MTCT6602c	No SQL Databases					
SOTT6302	Research Methodology and IPC	2	0	0	2	2
SOTT6303	Human Values & Professional Ethics (Audit Course – I)	2	0	0	0	2
MTCS6501/ MTCC6501	Technical Seminar/Case study	1	0	0	1	1
SOTL6301	Advanced Data Structures and Algorithms Lab	0	0	4	2	4
MTCJ6501	Cloud Architecture	1	0	2	2	3
--	Mentoring	0	0	0	0	1
--	Library	0	0	0	0	2
--	Physical Activity	0	0	0	0	2
--	Extra-Curricular Activities	0	0	0	0	2
--	Co-Curricular Activity	0	0	0	0	2
--	Self-Learning	0	0	0	0	3
TOTAL		**16**	**2**	**6**	**19**	**36**

II - Semester

Course Code	Course Name	Periods per week			Credits	Hours per week
		L	T	P		
SOTT6304	Advanced Machine Learning	2	1	0	3	3
MTCT6502	Advanced Computer Networks	2	1	0	3	3
Program Elective – III						
MTCT6603a	Ethical Hacking and Penetration Testing	3	0	0	3	3
MTCT6603b	Digital Forensics					
MTCT6603c	Database Security and Privacy					
Program Elective – IV						
MTCT6604a	Advanced Wireless Sensor Networks	3	0	0	3	3
MTCT6604b	Advanced Wireless Adhoc Networks					
MTCT6604c	Quantum Computing					
SOTT6305	English for Research Paper Writing (Audit Course II)	2	0	0	0	2
MTCP6501	Mini Project with Technical Seminar	0	0	8	4	8
SOTL6302	Advanced Machine Learning Lab	0	0	4	2	4
MTCL6501	Advanced Computer Networks Lab	0	0	4	2	4
--	Mentoring	0	0	0	0	1
--	Co-Curricular Activities	0	0	0	0	1
--	Self-Learning	0	0	0	0	1
--	Extra-Curricular Activities	0	0	0	0	2
--	Library	0	0	0	0	1
TOTAL		**12**	**2**	**16**	**20**	**36**

III - Semester

Course Code	Course Name	Periods per week			Credits	Hours per week
		L	T	P		
MTCM7501	MOOC – 1	3	0	0	3	3
MTCM7502	MOOC - 2	3	0	0	3	3
MTCP7501	Dissertation I / Industrial Project	0	0	20	10	20
--	Mentoring	0	0	0	0	1
--	Co-curricular activity	0	0	0	0	2
--	Self-Learning	0	0	0	0	1
--	Physical Activity	0	0	0	0	2
--	Extra-curricular activities	0	0	0	0	2
--	Soft Skills Training	0	0	0	0	1
--	Certification Course	0	0	0	0	1
TOTAL		**6**	**0**	**20**	**16**	**36**

IV - Semester

Course Code	Course Name	Periods per week			Credits	Hours per week
		L	T	P		
MTCP7502	Dissertation Phase II	0	0	32	16	32
TOTAL		**0**	**0**	**32**	**16**	**32**

I SEMESTER

MTCT6501	Mathematical Foundations of Computer Science	L	T	P	C
		2	1	0	3

Course Description:

This course introduces students to fundamental concepts in probability, statistics, and combinatorics, with a focus on their applications in Computer Science and Engineering. Topics include probability distributions, statistical inference, sampling methods, multivariate models, graph theory, and combinatorial problems. The course emphasizes real-world applications in data mining, machine learning, bioinformatics, and network protocols. Students will develop skills to apply mathematical techniques to complex problems in computer systems, security, and software engineering.

Course Objectives:

1. To understand probability mass, density functions, and the application of the Central Limit Theorem in univariate and multivariate scenarios.
2. To explore statistical estimations, including sampling distributions, Method of Moments, and Maximum Likelihood Estimation.
3. To study multivariate statistical models, including regression, classification, Principal Components Analysis, and model overfitting.
4. To learn graph theory concepts and combinatorial techniques to solve enumeration problems and network-related problems.
5. To apply mathematical and statistical methods to various Computer Science applications, including data mining, machine learning, and bioinformatics.

UNIT I **9 Hrs**

Probability mass, density, and cumulative distribution functions, Parametric families of distributions, Expected value, variance, conditional expectation, Applications of the univariate and multivariate Central Limit Theorem, Probabilistic inequalities, Markov chains

UNIT II **9 Hrs**

Random samples, sampling distributions of estimators, Methods of Moments and Maximum Likelihood.

UNIT III **9 Hrs**

Statistical inference, Introduction to multivariate statistical models: regression and classification problems, principal components analysis, The problem of overfitting model assessment.

UNIT IV **9 Hrs**

Graph Theory: Isomorphism, Planar graphs, graph colouring, hamilton circuits and euler cycles. Permutations and Combinations with and without repetition. Specialized techniques to solve combinatorial enumeration problems

UNIT V **9 Hrs**

Computer Science and Engineering Applications:

Data mining, Network protocols, analysis of Web traffic, Computer security, Software engineering, Computer architecture, operating systems, distributed systems, Bioinformatics, Machine learning.

Recent Trends in various distribution functions in mathematical field of computer science for varying fields like bioinformatic, soft computing, and computer vision.

Course Outcomes:

After completion of course, students would be able to:

1. Apply probability distributions, Central Limit Theorem, and Markov chains in practical problems.
2. Use statistical estimation techniques, such as the Method of Moments and Maximum Likelihood Estimation, in data analysis.
3. Analyze multivariate models for regression, classification, and dimensionality reduction (PCA) to address overfitting.
4. Solve graph theory and combinatorial problems, including isomorphism, planar graphs, Hamiltonian cycles, and permutations.
5. Implement mathematical models in computer science applications such as machine learning, network protocols, and bioinformatics.

Text Books:

1. John Vince, Foundation Mathematics for Computer Science, Springer.
2. K. Trivedi, Probability and Statistics with Reliability, Queuing, and Computer Science Applications. Wiley.

Reference Books:

1. M. Mitzenmacher and E. Upfal.Probability and Computing: Randomized Algorithms and Probabilistic Analysis.
2. Alan Tucker, Applied Combinatorics, Wiley.

SOTT6301 Advanced Data Structures and Algorithms L T P C

2 1 0 3

Course Description:

This course provides an in-depth study of advanced data structures and algorithmic techniques essential for efficient problem-solving in data science. It covers key topics such as balanced trees, hash-based structures, graphs, dynamic programming, and approximation algorithms. The course emphasizes the application of these concepts in large-scale data processing, optimization, and machine learning. Students will also explore parallel and distributed algorithms, along with performance analysis and complexity optimization strategies. Hands-on implementation and real-world problem-solving are integral parts of this course.

Course Objectives:

1. Understand and implement advanced data structures for efficient data handling.
2. Apply graph algorithms to solve real-world network and optimization problems.
3. Develop efficient algorithmic solutions using dynamic programming, greedy, and divide-and-conquer techniques.
4. Analyze NP-completeness and design approximation and randomized algorithms for intractable problems.
5. Implement and optimize parallel and distributed algorithms for large-scale data processing.

UNIT I 9 Hrs

Advanced Data Structures

Algorithms, Performance analysis- time complexity and space complexity, Asymptotic Notation- Big Oh, Omega and Theta notations, Complexity Analysis Examples; Review of basic data structures (arrays, linked lists, stacks, queues), Trees: AVL Trees, Red-Black Trees, B-Trees, Segment Trees, Fenwick Trees, Hashing: Hash functions, collision resolution techniques, perfect hashing, Disjoint Set Union (Union-Find) and applications

UNIT II 9 Hrs

Graph Algorithms

Graph representations (adjacency list, adjacency matrix), Traversal algorithms: BFS, DFS, Topological Sorting, Shortest path algorithms: Dijkstra's, Bellman-Ford, Floyd-Warshall, Minimum spanning tree: Prim's and Kruskal's algorithms, Network flow algorithms: Max-flow (Ford-Fulkerson, Edmonds-Karp)

UNIT III 9 Hrs

Algorithmic Techniques

Divide and Conquer: Applications in searching and sorting (Merge Sort, Quick Sort), Greedy Algorithms: Huffman Coding, Activity Selection, Job Scheduling, Dynamic Programming: Knapsack problem, Matrix Chain Multiplication, LCS, LIS, Backtracking and Branch & Bound: N-Queens, Traveling Salesman Problem

UNIT IV **9 Hrs**

Approximation and Randomized Algorithms

NP-Completeness and NP-Hard problems, Approximation algorithms: Vertex Cover, TSP, Set Cover, Randomized algorithms: Monte Carlo and Las Vegas algorithms, Probabilistic data structures: Bloom Filters, Skip Lists

UNIT V **9 Hrs**

Parallel and Distributed Algorithms

Parallel sorting and searching algorithms, MapReduce and distributed graph algorithms, Concurrent data structures and synchronization, GPU-based algorithms and parallel computing techniques

Course Outcomes:

After completion of course, students would be able to:

1. Design and implement advanced data structures for complex applications.
2. Solve graph-related problems using efficient algorithms.
3. Apply advanced algorithmic techniques to real-world computational challenges.
4. Evaluate algorithmic performance and optimize computational complexity.
5. Implement scalable parallel and distributed solutions for big data applications..

Text Books:

1. **Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C.** – *Introduction to Algorithms*, 4th Edition, MIT Press, 2022.
2. **Sedgewick, R., & Wayne, K.** – *Algorithms*, 4th Edition, Addison-Wesley, 2011.
3. **Aho, A. V., Hopcroft, J. E., & Ullman, J. D.** – *Data Structures and Algorithms*, Pearson Education, 2002.
4. **Goodrich, M. T., & Tamassia, R.** – *Algorithm Design and Applications*, Wiley, 2014.
5. **Dasgupta, S., Papadimitriou, C., & Vazirani, U.** – *Algorithms*, McGraw-Hill, 2006.

Reference Books:

1. **Tarjan, R. E.** – *Data Structures and Network Algorithms*, SIAM, 1983.
2. **Kleinberg, J., & Tardos, E.** – *Algorithm Design*, Pearson, 2006.
3. **Mehta, D. P., & Sahni, S.** – *Handbook of Data Structures and Applications*, Chapman & Hall/CRC, 2018.
4. **Skiena, S. S.** – *The Algorithm Design Manual*, 3rd Edition, Springer, 2020.
5. **Motwani, R., & Raghavan, P.** – *Randomized Algorithms*, Cambridge University Press, 1995.

Online Resources:

1. **MIT OpenCourseWare** – *Advanced Data Structures and Algorithms*
2. **Stanford Online** – *Algorithms Specialization by Tim Roughgarden (Coursera)*

Program Elective - I

MTCT6601a **Deep Learning** **L T P C**

3 0 0 3

Course Description:

This course provides an in-depth exploration of deep learning techniques and their applications in various domains like computer vision, natural language processing (NLP), and reasoning tasks. It covers foundational concepts such as feedforward neural networks, convolutional and recurrent neural networks, and advanced techniques like adversarial networks and autoencoders. The course emphasizes practical applications such as image segmentation, object detection, and dialogue generation, along with strategies for mitigating common issues in deep learning, such as the vanishing gradient problem and local minima.

Course Objectives:

1. To understand the fundamentals of feedforward neural networks, gradient descent, backpropagation, and techniques for mitigating training challenges.
2. To explore advanced neural network architectures including Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), and deep unsupervised learning models.
3. To apply deep learning techniques to computer vision tasks such as image segmentation, object detection, and image generation using GANs.
4. To understand and implement NLP models, including word vector representations and their applications in tasks like word similarity and semantic analysis.
5. To explore advanced reasoning tasks in NLP, such as Named Entity Recognition, sentiment analysis, and dialogue generation using RNNs and CNNs.

UNIT I **9 Hrs**

Introduction: Feed forward Neural networks, Gradient descent and the back propagation algorithm, Unit saturation, the vanishing gradient problem, and ways to mitigate it. RelU Heuristics for avoiding bad local minima, Heuristics for faster training, Nestors accelerated gradient descent, Regularization, Dropout; basics of neural networks-Types of CNN Architectures - Standard CNNs, LeNet-5, AlexNet, VGGNet (VGG-16, VGG-19), GoogLeNet (Inception Networks), ResNet (Residual Networks), DenseNet, MobileNet, EfficientNet;

UNIT II **9 Hrs**

Convolutional Neural Networks: Architectures, convolution/pooling layers, Recurrent Neural Networks: LSTM, GRU, Encoder Decoder architectures. Deep Unsupervised Learning: Auto encoders, Variational Auto-encoders, Adversarial Generative Networks, Auto-encoder and DBM Attention and memory models, Dynamic Memory Models.

UNIT III **9 Hrs**

Applications of Deep Learning to Computer Vision: Image segmentation, object detection, automatic image captioning, Image generation with Generative adversarial networks, video to text with LSTM models, Attention Models for computer vision tasks.

UNIT IV **9 Hrs**

Applications of Deep Learning to NLP: Introduction to NLP and Vector Space Model of Semantics, Word Vector Representations: Continuous Skip-Gram Model, Continuous Bag-of-Wordsmodel (CBOW), Glove, Evaluations and Applications in word similarity.

UNIT V **9 Hrs**

Analogy reasoning: Named Entity Recognition, Opinion Mining using Recurrent Neural Networks: Parsing and Sentiment Analysis using Recursive Neural Networks: Sentence Classification using Convolutional Neural Networks, Dialogue Generation with LSTMs.

Course Outcomes:

After completion of course, students would be:

1. Gain proficiency in training and optimizing neural networks and handling issues like vanishing gradients and local minima.
2. Understand and apply advanced neural network architectures such as CNNs, LSTMs, GRUs, and autoencoders.
3. Implement deep learning models for computer vision applications like object detection and image captioning.
4. Apply deep learning techniques to NLP tasks such as word similarity, sentiment analysis, and parsing.
5. Solve complex NLP tasks such as dialogue generation and opinion mining using deep learning models.

Text Books:

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

Reference Books:

1. Bishop, C, M., Pattern Recognition and Machine Learning, Springer, 2006.
2. Yegnanarayana, B., Artificial Neural Networks PHI Learning Pvt. Ltd, 2009.
3. Golub, G.,H., and Van Loan,C.,F., Matrix Computations, JHU Press,2013.
4. Satish Kumar, Neural Networks: A Classroom Approach, Tata McGraw-Hill Education, 2004.

MTCT6601b **Natural Language Processing** **L T P C**

3 0 0 3

Course Description:

This course provides an in-depth exploration of natural language processing (NLP) with a focus on syntactic and semantic analysis, word and document structure, and discourse processing. It covers various models and approaches to parsing, representing syntactic structures, and addressing multilingual issues. Students will also study semantic parsing, predicate-argument structures, and language modeling techniques, along with challenges in discourse processing, cohesion, and reference resolution. Emphasis is placed on applying these techniques to real-world NLP tasks.

Course Objectives:

1. To understand the structure of words and documents, and explore morphological models and methods for analyzing document complexity and performance.
2. To study syntax analysis, parsing algorithms, and syntactic structure representation, including multilingual parsing and ambiguity resolution techniques.
3. To explore semantic parsing and word sense systems, including their role in semantic interpretation and system paradigms.
4. To examine predicate-argument structures, meaning representation systems, and relevant software used in NLP.
5. To learn about discourse processing, cohesion, reference resolution, and the development of language models, including N-Gram models and language adaptation.

UNIT I **9 Hrs**

Finding the Structure of Words: Words and Their Components, Issues and Challenges, Morphological Models. Finding the Structure of Documents: Introduction, Methods, Complexity of the Approaches, Performances of the Approaches.

UNIT II **9 Hrs**

Syntax Analysis: Parsing Natural Language, Treebanks: A Data-Driven Approach to Syntax, Representation of Syntactic Structure, Parsing Algorithms, Models for Ambiguity Resolution in Parsing, Multilingual Issues.

UNIT III **9 Hrs**

Semantic Parsing: Introduction, Semantic Interpretation, System Paradigms, Word Sense Systems, Software.

UNIT IV **9 Hrs**

Predicate-Argument Structure, Meaning Representation Systems, Software.

UNIT V **9 Hrs**

Discourse Processing: Cohesion, Reference Resolution, Discourse Cohesion and Structure Language Modeling: Introduction, N-Gram Models, Language Model Evaluation, Parameter Estimation, Language Model Adaptation, Types of Language Models, Language-Specific

Modeling Problems, Multilingual and Cross Lingual Language Modeling; Case studies- Machine Translation for Low-Resource Languages - Hate Speech Detection in Social Media

Course Outcomes:

After completion of course, students would be able to:

1. Show sensitivity to linguistic phenomena and an ability to model them with formal grammars.
2. Understand and carry out proper experimental methodology for training and evaluating empirical NLP systems.
3. Able to manipulate probabilities, construct statistical models over strings and trees, and estimate parameters using supervised and unsupervised training methods.
4. Able to design, implement, and analyze NLP algorithms and different language modeling Techniques.
5. Able to design different language modeling Techniques.

Text Book:

1. Multilingual natural Language Processing Applications: From Theory to Practice – Daniel M. Bikel and Imed Zitouni, Pearson Publication.
2. Natural Language Processing and Information Retrieval: Tanvier Siddiqui, U.S. Tiwary

Reference Book:

1. Speech and Natural Language Processing - Daniel Jurafsky & James H Martin, Pearson Publications.

MTCT6601c	Generative AI	L	T	P	C
		3	0	0	3

Course Description:

Generative AI is a type of artificial intelligence technology that is capable of producing various types of content, including text, imagery, audio and synthetic data. The recent buzz around Generative AI has been driven by the simplicity of new user interfaces for creating high-quality text, graphics and videos in a matter of seconds. This course aims to provide the fundamental concept Generative AI. In also offers various insights about Generative AI Technology and Language models. Further it also cover the impact of Generative AI on major industries

Course Objectives:

1. To familiarize the basics of Generative AI and its role for Data preparation.
2. To Understand the core fundamental concepts of Generative AI.
3. To analyse the Generative AI technology and large language models.
4. To analyse the role of Generative AI in transformation of business models
5. To apply the Generative AI and analyse its impact on major industries

UNIT I Introduction **8 Hrs**

Introduction to Generative AI: Definition - Opportunity – Using Generative AI- The ChatGPT Effect- The Drivers- Skeptics- Dangers of Hype.

Data: Value of Data- The Amazing Growth of Data- Big Data- Databases- Cloud Models- Data Strategy- Data Collection- Common Data Sources- Data Evaluation- Data Wrangling- Data Labeling- Quantity- Privacy Laws and Regulations- Generative AI for Data Wrangling- Generative AI for Data Preparation-Chief Data Officer.

Unit II AI Fundamentals **9 Hrs**

Understanding the core Foundations of Generative AI: Early AI Programs- AI struggle- Concept of AI- Machine Learning- Supervised Learning-Regression Analysis-Support Vector Machines- Random Forest- K- Nearest Neighbor- Navie Bayes Classifiers- Unsupervised Learning- Clustering- Anomaly Detection- Association- Autoencoders- Reinforcement Learning- Deep Learning- The Brain and AI- Drawbacks with Deep Learning- Overfitting and Underfitting- AI Tools- AI System for Beginners.

UNIT III Generative AI Technology and Language Models **10 Hrs**

Core Generative AI Technology: Generative vs. Discriminative Models- Probability Theory- Types of Generative AI Models- DALL- E 2- Stability AI and Midjourney- Speech- Trilemma of Generative AI Models

Large Language Models: Language and Intelligence- Natural Language Processing- How NLP works- Word2Vec Model- Transformers- Dials- BERT- GPT Systems and ChatGPT- Dolly- Gopher and Gato- Cohere- AI2 I Labs- BLOOM- Megatron Turing Natural Language Generation Model (MT-NLG) – GPT Sw3- Issues and New Startup Model- Prompt Engineering- Character AI- Empathy.

UNIT IV Auto Code Generation and Transformation of Business **10 Hrs**

Generative AI and Revolutionize Development: Developer Shortage- AI Code Generation Systems- Copilot- AlphaCode – Tabnine – Magic – PolyCoder- Blaze- Debugging Code- Data Labeling – Prompt Engineering for Coding – Atera- Large Scale Projects- Drawbacks and Risks.

The Transformation of Business: Leveraging Generative AI for Company's Operation - Legal- Customer Experience- Sales and Marketing- Anyword- Wope- INK- Regie.ai- Lavender and SellScale- Grammarly- Writer- Cresta- Forethought- Intercom- Product Development- Spoke AI- Presentations – Buy vs. Build- Implementing Generative AI- Data Preparation and AI Modeling- The Generative AI Process

UNIT V Impact of Generative AI on Major Industries **8 Hrs**

Impact of Generative AI on Major Industries: Music- WaveAI- Education- GPTZero- Duolingo-Journalism- Gaming- Roblox- Healthcare- Creating X-Rays- Finance.

The Future of Generative AI – Trends and Emerging Use Cases:

The era of multimodal interactions - GPT-4 - Video generation models- Industry-specific generative AI apps - The rise of small language models (SLMs) - Integrating generative AI with intelligent edge devices - Quantum Computing and AI

Course Outcomes:

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

1. Understand the fundamental concepts of Generative AI.
2. Describe Generative AI and distinguish it from discriminative AI.
3. Identify the Core Generative AI technology and large language models.
4. Analyse the generative AI and its use cases in the real world.
5. Explore the impact of Generative AI on Major industry.

Text Books:

1. Taulli, Tom. Generative AI: How ChatGPT and other AI tools will revolutionize business. Berkeley, CA: Apress, 2023.
2. Foster, David. Generative deep learning. " O'Reilly Media, Inc.", 2022.

References:

1. Chang, Chew-Hung, and Gillian Kidman. "The rise of generative artificial intelligence (AI) language models-challenges and opportunities for geographical and environmental education." International Research in Geographical and Environmental Education 32.2 (2023).
2. Brynjolfsson, Erik, Danielle Li, and Lindsey R. Raymond. Generative AI at work. No. w31161. National Bureau of Economic Research, 2023.
3. Explainable Artificial Intelligence: An Introduction to Interpretable Machine Learning, Uday Kamath: John Liu, Springer, ISBN 9783030833558
4. Hacker, Philipp, Andreas Engel, and Marco Mauer. "Regulating ChatGPT and other large generative AI models." Proceedings of the 2023 ACM Conference on Fairness, Accountability, and Transparency. 2023.

Program Elective - II

MTCT6602a	Enterprise Cloud Concepts	L	T	P	C
		3	0	0	3

Course Description:

This course introduces cloud computing, focusing on its foundational concepts, technologies, and business applications. Students will explore cloud delivery models, enabling technologies, and cloud management mechanisms. The course also delves into fundamental cloud architectures, cloud-enabled smart enterprises, and strategies for transitioning to cloud-centric enterprises. By examining case studies and examples, students will gain practical insights into implementing cloud solutions for enterprise transformation and business continuity.

Course Objectives:

1. To understand the origins, basic concepts, terminology, and benefits of cloud computing, along with its different delivery and deployment models.
2. To explore the enabling technologies of cloud computing, including broadband networks, virtualization, and cloud infrastructure mechanisms.
3. To study cloud management systems, including resource management, SLA management, billing, and cloud architecture models.
4. To investigate the transformation of enterprises into cloud-enabled smart enterprises and develop strategies for cloud-incorporated business strategies.
5. To examine the methodologies for transitioning to cloud-centric enterprises, including contract management, cloud infrastructures, and the emergence of private and enterprise clouds.

UNIT I **9 Hrs**

Understanding Cloud Computing: Origins and influences, Basic Concepts and Terminology, Goals and Benefits, Risks and Challenges. Fundamental Concepts and Models: Roles and Boundaries, Cloud Characteristics, Cloud Delivery Models, Cloud Deployment Models.

UNIT II **9 Hrs**

Cloud-Enabling Technology: Broadband Networks and Internet Architecture, Data Center Technology, Virtualization Technology. Cloud Computing Mechanisms: Cloud Infrastructure Mechanisms: Logical Network Perimeter, Virtual Server, Cloud Storage Device, Cloud Usage Monitor, Resource Replication.

UNIT III **9 Hrs**

Cloud Management Mechanisms: Remote Administration System, Resource Management System, SLA Management System, Billing Management System, Case Study Example Cloud Computing Architecture Fundamental Cloud Architectures: Workload Distribution Architecture, Resource Pooling Architecture, Dynamic Scalability Architecture, Elastic Resource Capacity Architecture, Service Load Balancing Architecture, Cloud Bursting Architecture, Elastic Disk Provisioning Architecture, Redundant Storage Architecture, Case Study Example.

UNIT IV **9 Hrs**

Cloud-Enabled Smart Enterprises: Introduction, Revisiting the Enterprise Journey, Service-Oriented Enterprises, Cloud Enterprises, Smart Enterprises, The Enabling Mechanisms of Smart Enterprises Cloud-Inspired Enterprise Transformations: Introduction, The Cloud Scheme for Enterprise Success, Elucidating the Evolving Cloud Idea, Implications of the Cloud on Enterprise Strategy, Establishing a Cloud-Incorporated Business Strategy.

UNIT V **9 Hrs**

Transitioning to Cloud-Centric Enterprises: The Tuning Methodology, Contract Management in the Cloud Cloud-Instigated IT Transformations Introduction, Explaining Cloud Infrastructures, A Briefing on Next-Generation Services, Service Infrastructures, Cloud Infrastructures, Cloud Infrastructure Solutions, Clouds for Business Continuity, The Relevance of Private Clouds, The Emergence of Enterprise Clouds.

Course Outcomes:

1. Understand the core concepts, goals, and challenges of cloud computing, including its delivery and deployment models.
2. Demonstrate knowledge of the technologies that enable cloud computing, including data center technology and virtualization.
3. Apply cloud management mechanisms to real-world scenarios, focusing on resource and SLA management.
4. Design strategies for transforming traditional enterprises into cloud-enabled smart enterprises, integrating cloud into business operations.
5. Evaluate and implement cloud-centric business strategies and infrastructure solutions, focusing on enterprise clouds and business continuity.

Text Books:

1. Erl Thomas, Puttini Ricardo, Mahmood Zaigham, Cloud Computing: Concepts, Technology & Architecture 1st Edition.
2. Pethuru Raj, Cloud Enterprise Architecture, CRC Press.

Reference Book:

1. James Bond,The Enterprise Cloud, O'Reilly Media, Inc.

MTCT6602b **Data Science** **L T P C**

3 0 0 3

Course Description:

This course provides an introduction to data science, covering the core concepts, technologies, and processes involved in extracting insights from data. Topics include data collection, management, and analysis, with a focus on statistics, machine learning algorithms, and data visualization. Students will learn how to manage and manipulate data, apply basic machine learning techniques, and create effective visualizations to communicate data-driven insights. The course also addresses current trends in data collection, analysis, and visualization tools.

Course Objectives:

1. To introduce students to the fundamental concepts and technologies in data science, including the data science process, types of data, and real-world applications.
2. To explore data collection techniques, sources of data, APIs, and methods for managing and storing data across multiple sources.
3. To introduce key data analysis concepts, including statistics, machine learning algorithms like linear regression, SVM, and Naive Bayes.
4. To teach various data visualization techniques, focusing on visual encoding and effective ways to represent different types of data.
5. To explore applications of data science, with hands-on experience in visualization technologies like Bokeh and current trends in data analysis and visualization.

UNIT I **9 Hrs**

Introduction to core concepts and technologies: Introduction, Terminology, data science process, data science toolkit, Types of data, Example applications. **Data Science Tools and Techniques-**Overview and Demonstration of Open source tools such as R, Octave, Scilab. Python libraries: SciPy and sci-kitLearn, PyBrain, Pylearn2; Weka

UNIT II **9 Hrs**

Data collection and management: Introduction, Sources of data, Data collection and APIs, Exploring and fixing data, Data storage and management, Using multiple data sources.

UNIT III **9 Hrs**

Data analysis: Introduction, Terminology and concepts, Introduction to statistics, Central tendencies and distributions, Variance,Distribution properties and arithmetic, Samples/CLT, Basic machine learning algorithms, Linear regression, SVM, Naive Bayes.

UNIT IV **9 Hrs**

Data visualisation: Introduction, Types of data visualisation, Data for visualisation: Data types, Data encodings, Retinal variables, Mapping variables to encodings, Visual encodings.

UNIT V **9 Hrs**

Applications of Data Science, Technologies for visualisation, Bokeh (Python)

Recent trends in various data collection and analysis techniques, various visualization techniques, application development methods of used in data science.

Course Outcomes:

1. Understand the fundamental concepts, terminologies, and processes of data science and their real-world applications.
2. Gain proficiency in data collection, management, and integration from multiple sources using APIs and other tools.
3. Apply basic statistical concepts and machine learning algorithms to analyze and interpret data.
4. Create effective data visualizations using appropriate encoding techniques and visualization tools.
5. Develop and apply data science applications using modern technologies and stay updated with trends in data collection, analysis, and visualization.

Text Book:

1. Cathy O'Neil and Rachel Schutt. Doing Data Science, Straight Talk From The Frontline. O'Reilly.

Reference Book:

1. Jure Leskovek, Anand Rajaraman and Jeffrey Ullman. Mining of Massive Datasets. v2.1, Cambridge University Press.

MTCT6602c	No SQL Databases	L	T	P	C
		3	0	0	3

Course Description:

This course introduces the evolving world of NoSQL databases, focusing on non-relational models designed to handle large-scale, distributed, and schema-less data. Students will learn the principles, architecture, and use cases of various NoSQL database types including key-value stores, document stores, column-family databases, and graph databases. The course emphasizes practical application through industry case studies, explores integration with Big Data platforms like Hadoop and Spark, and covers modern tools such as MongoDB, Cassandra, Redis, and Neo4j. Security, performance, and best practices in NoSQL environments are also addressed to prepare students for real-world deployment.

Course Objectives:

1. To understand the need and evolution of NoSQL databases in contrast to traditional RDBMS.
2. To explore various NoSQL database models including key-value, document, column-family, and graph.
3. To analyze industry-level applications and architectural considerations of NoSQL systems.
4. To study real-time integration of NoSQL databases with Big Data and Cloud platforms.
5. To gain practical skills in implementing NoSQL solutions using MongoDB, Cassandra, Redis, and Neo4j.

UNIT I INTRODUCTION TO NoSQL DATABASES 9 Hrs

Introduction – Characteristics of NoSQL – ACID vs BASE – CAP Theorem – Types of NoSQL databases – Advantages and Limitations – Differences between RDBMS and NoSQL – Use cases and industry drivers for NoSQL adoption. **Case Study**: Migrating an E-Commerce Catalog System from RDBMS to MongoDB

UNIT II KEY-VALUE AND DOCUMENT-ORIENTED DATABASES 9 Hrs

Key-Value Stores: Redis, Amazon DynamoDB – Features and Use Cases – Architecture – Operations and Data Modeling. Document Stores: MongoDB – BSON Format – CRUD Operations – Indexing – Aggregation – Sharding – Replication. **Case Study**: Building a Content Management System (CMS) using MongoDB

UNIT III COLUMN-FAMILY AND GRAPH DATABASES 9 Hrs

Column-Family Stores: Apache Cassandra – Data Modeling – CQL – Consistency and Availability – Use in Time-Series Applications. Graph Databases: Neo4j – Graph Data Modeling – Cypher Query Language – Use Cases: Fraud Detection, Social Networks. **Case Study**: Analyzing a Social Network using Neo4j

UNIT IV BIGDATA INTEGRATION & PERFORMANCE CONSIDERATIONS 9 Hrs

Integration with Hadoop and Spark – Using MongoDB with Apache Spark – Performance Tuning – Indexing Strategies – Horizontal Scaling – Query Optimization – Benchmarking NoSQL Systems – Cloud-based NoSQL (Firebase, AWS DynamoDB). **Case Study**: Real-Time Recommendation Engine using Spark and MongoDB

UNIT V APPLICATIONS, SECURITY, AND BEST PRACTICES 9 Hrs

Security in NoSQL Databases – Authentication and Authorization – Backup and Disaster Recovery – Auditing and Monitoring – Data Governance – Industry Best Practices – Comparative Evaluation of NoSQL Models. **Case Study**: Securing a NoSQL-based IoT Data Pipeline (MongoDB + Redis)

Course Outcomes:

Upon successful completion of this course, a student will be able to:

1. Understand and differentiate NoSQL systems from traditional relational databases.
2. Model and manage data using appropriate NoSQL techniques and tools.
3. Apply NoSQL databases to real-world problems including social networks, IoT, and recommendation systems.
4. Integrate NoSQL databases with Big Data tools and platforms.
5. Ensure security, availability, and scalability in enterprise-grade NoSQL deployments.

Text Books:

1. Pramod J. Sadalage & Martin Fowler, *NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence*, Addison-Wesley, 2013.
2. Shashank Tiwari, *Professional NoSQL*, Wiley, 2011.

Reference Books:

1. Dan McCreary, Ann Kelly, *Making Sense of NoSQL*, Manning Publications, 2013.
2. Guy Harrison, *Next Generation Databases*, Apress, 2015.
3. Kristina Chodorow, *MongoDB: The Definitive Guide*, O'Reilly, 3rd Edition, 2019.
4. Eben Hewitt, *Cassandra: The Definitive Guide*, O'Reilly, 3rd Edition.
5. Rik Van Bruggen, *Learning Neo4j*, Packt Publishing, 3rd Edition.

SOTT6302	Research Methodology and IPC	L	T	P	C
		2	0	0	2

Course Description

This course provides a comprehensive overview of research methodology tailored for data science. It covers the entire research process—from problem formulation and literature review to data collection, analysis, and reporting. In addition, the course introduces aspects of Intellectual Property and Communication (IPC), including publication ethics, academic writing, and effective dissemination of research outcomes. Emphasis is placed on both theoretical foundations and practical applications to prepare students for rigorous academic or industrial research.

Course Objectives

1. To develop the ability to formulate research problems and design appropriate methodologies.
2. To familiarize students with qualitative and quantitative research methods and data analysis techniques.
3. To guide students in the preparation of literature reviews, research proposals, and research reports.
4. To introduce the ethical, legal, and intellectual property issues related to research.
5. To enhance communication skills for effective dissemination of research findings.

UNIT I Introduction to Research Methodology **6 Hrs**

Definition, scope, and importance of research in data science of research (exploratory, descriptive, explanatory, experimental and applied)-Steps in the research process and research design-Formulating research questions and hypotheses-Overview of literature review techniques

UNIT II Research Design and Data Collection Methods **6 Hrs**

Qualitative vs. quantitative research methodologies- sampling techniques and research instruments (surveys, interviews, observations)-Experimental design and case study approaches-Data collection methods and tools-Reliability, validity, and bias in research.

UNIT III Data Analysis and Interpretation **6 Hrs**

Statistical techniques and data analysis methods tools for data analysis (SPSS, R, Python)-Interpreting quantitative and qualitative data (ATLAS.ti) -Reporting results and drawing conclusions to data visualization for research findings

UNIT IV Intellectual Property, Publication Ethics, and Communication **6 Hrs**

Overview of intellectual property rights (patents, copyrights, trademarks)-Publication ethics and academic integrity- Preparing research proposals, manuscripts, and technical reports-Communication skills for oral presentations and poster sessions for submitting to journals and conferences.

UNIT V Research Project and Practical Communication **6 Hrs**

Designing a mini research project in data science evaluation of research literature and case studies and peer-review exercises-Workshop on effective oral and poster presentations-Discussion on current trends and future challenges in research

Course Outcomes

Upon completion of this course, students will be able to:

1. Formulate and refine research questions and hypotheses relevant to data science.
2. Design research studies using appropriate methodologies and tools.
3. Conduct comprehensive literature reviews and critically evaluate academic sources.
4. Analyze data using both qualitative and quantitative methods.
5. Prepare research proposals, technical reports, and academic papers while adhering to ethical and intellectual property standards.

Textbooks & References

1. **Kothari, C.R.** – *Research Methodology: Methods and Techniques*, 2nd Edition, New Age International, 2004.
2. **Creswell, J.W.** – *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*, 4th Edition, SAGE Publications, 2014.
3. **Cooper, D.R. & Schindler, P.S.** – *Business Research Methods*, 12th Edition, McGraw-Hill, 2014.
4. **Silverman, D.** – *Interpreting Qualitative Data*, 5th Edition, SAGE Publications, 2016.
5. **Day, R.A. & Gastel, B.** – *How to Write and Publish a Scientific Paper*, 7th Edition, Cambridge University Press, 2012.
6. **Hennink, Monique, Inge Hutter, and Ajay Bailey**. *Qualitative research methods*. Sage, 2020.
7. **Tewari, Rupinder, and Mamta Bhardwaj**. *Intellectual Property: A Primer for Academia*. Publication Bureau, Panjab University, 2021.

SOTT6303	Human Values & Professional Ethics (Audit Course – I)	L	T	P	C
		2	0	0	0

Course Description

This course examines the role of human values and professional ethics in the context of data science and technology. It discusses ethical theories, professional responsibilities, and the societal impacts of technology. Special emphasis is placed on understanding ethical dilemmas, maintaining professional integrity, and fostering social responsibility in both academic and industrial environments.

Course Objectives

1. To introduce fundamental ethical theories and their relevance to professional practice.
2. To analyse ethical dilemmas and decision-making frameworks in modern workplaces.
3. To cultivate an understanding of professional responsibility and integrity.
4. To explore the legal and ethical standards governing technology and data use.
5. To prepare students to address ethical challenges in their professional careers.

UNIT I Fundamentals of Human Values and Ethics **6 Hrs**

Introduction to ethics and human values- Overview of ethical theories: utilitarianism, deontology, virtue ethics-Importance of ethics in personal and professional life.
Case studies on ethical decision-making.

UNIT II Professional Ethics and Responsibilities **6 Hrs**

Codes of conduct and professional ethics in various industries-Role of accountability, transparency, and integrity in the workplace-Ethical issues in information technology and data science-Legal frameworks and standards influencing professional practice.

UNIT III Ethical Dilemmas **6 Hrs**

Data privacy, security, and bias in AI applications-Intellectual property, plagiarism, and research misconduct-Conflict of interest, corporate governance, and whistleblowing-Analysis of real-world ethical dilemmas through case studies.

UNIT IV Social Responsibility and Impact of Technology **6 Hrs**

Corporate Social Responsibility (CSR) and sustainable development- The societal impact of data-driven decision-making- Global and multicultural perspectives on ethics- Role of ethics in innovation and technological advancement.

UNIT V Ethics in Research and Professional Practice **6 Hrs**

Academic integrity and research ethics- Collaborative work, interdisciplinary ethics, and professional accountability- Workshops, role plays, and discussions on ethical decision-making- Developing a personal ethical framework and professional development plan.

Course Outcomes

Upon completion of this course, students will be able to:

1. Explain key ethical theories and apply them to real-world professional scenarios.

2. Identify and analyse ethical issues in data science, including privacy, bias, and intellectual property.
3. Demonstrate professional responsibility and integrity in academic and workplace settings.
4. Apply ethical frameworks to resolve conflicts and dilemmas in practice.
5. Appreciate the social and global impacts of technological innovations.

Textbooks & References

1. Velasquez, M.G. et al. – *Ethical Issues in Business*, 6th Edition, Pearson, 2015.
2. Ferrell, O.C., Fraedrich, J., & Ferrell, L. – *Business Ethics: Ethical Decision Making & Cases*, 11th Edition, Cengage Learning, 2019.
3. Solomon, R.C. & Flores, F. – *A Passion for Justice: Embracing Human Rights, Diversity, and Ethics in the Workplace*, 1st Edition, Wiley, 2012.
4. Beauchamp, T.L. & Childress, J.F. – *Principles of Biomedical Ethics*, 7th Edition, Oxford University Press, 2013.
5. Singer, P. – *Practical Ethics*, 3rd Edition, Cambridge University Press, 2011.

SOTL6301 Advanced Data Structures and Algorithms Lab

L	T	P	C
0	0	4	2

Course Description:

This laboratory course is designed to provide hands-on experience in implementing, testing, and optimizing advanced data structures and algorithms. Through a series of practical exercises and projects, students will translate theoretical concepts into efficient, real-world code using programming languages such as C++, Java, or Python.

Course Objectives:

1. To reinforce the theoretical concepts of advanced data structures and algorithms through practical coding exercises.
2. To develop the ability to analyze algorithm performance using complexity analysis and benchmarking.
3. To enhance coding proficiency and optimization skills.
4. To enable students to design and implement complex data-driven solutions.
5. To encourage collaborative problem solving and project-based learning in a lab setting.

1. Implementation of the following:
   - Revision of fundamental data structures (arrays, linked lists, stacks, queues)
   - Analysis and Big-O notation
2. Implementation of basic sorting and searching algorithms
   - Lab activity: performance measurement and benchmarking of simple algorithms
3. Illustration of Advanced Tree Structures and Graph Algorithms
   - Implementation of balanced trees (AVL, Red-Black Trees)
4. Illustration of tree-based search and graph traversal algorithms
5. Performance analysis and optimization discussions
6. Demonstration of Dynamic Programming and Greedy Algorithms
   A) Implementation of dynamic programming solutions for classic problems (e.g., knapsack, longest common subsequence),
   B) Exercises comparing dynamic programming and greedy approaches
7. Randomized Algorithms and Approximation Techniques
   - Coding randomized algorithms (e.g., quickselect, random graph generation)
   - Implementation of heuristic and approximation algorithms
8. Lab activity: performance evaluation and variability analysis
   - Discussion on the robustness of randomized vs. deterministic approaches
9. Design and implementation of an end-to-end project integrating advanced data structures, Code profiling, memory management, and optimization techniques
10. Collaborative project development and peer review
    - Final presentation and demonstration of project outcomes

Course Outcomes

After completing the lab, students will be able to:

1. Implement advanced data structures (e.g., balanced trees, heaps, graphs) in a programming language.

2. Analyze and compare the efficiency of different algorithms using Big-O notation and empirical testing.
3. Develop solutions for complex algorithmic problems using dynamic programming, greedy methods, and randomized algorithms.
4. Optimize code performance through profiling and iterative improvement.
5. Collaborate effectively on programming projects and present their solutions.

Textbooks & References

1. **Cormen, T.H., Leiserson, C.E., Rivest, R.L., & Stein, C.** – *Introduction to Algorithms*, 3rd Edition, MIT Press, 2009.
2. **Sedgewick, R. & Wayne, K.** – *Algorithms*, 4th Edition, Addison-Wesley, 2011.
3. **Goodrich, M.T., Tamassia, R., & Goldwasser, M.H.** – *Data Structures and Algorithms in Java*, 6th Edition, Wiley, 2014.
4. **Skiena, S.S.** – *The Algorithm Design Manual*, 2nd Edition, Springer, 2008.
5. **Aho, A.V., Hopcroft, J.E., & Ullman, J.D.** – *Data Structures and Algorithms*, 1st Edition, Addison-Wesley, 1983.

MTCJ6501	Cloud Architecture	L	T	P	C
		1	0	2	2

Course Description:

This course offers a comprehensive introduction to cloud computing, covering core concepts, service and deployment models, and virtualization. Students will gain hands-on experience with cloud infrastructure, serverless technologies, containers, and DevOps practices. The curriculum emphasizes real-world application through labs and projects involving leading platforms like AWS, Azure, and GCP. By the end, students will be equipped to design, deploy, and manage scalable cloud solutions.

Course Objectives:

1. Introduce cloud computing concepts, including its evolution, service models, and deployment models, along with foundational knowledge of virtualization.
2. To provide an understanding of cloud infrastructure including storage, networking, and security components like IAM and firewall rules.
3. To introduce architectural best practices and technologies such as serverless computing and containers used in designing scalable cloud applications.
4. Familiarize students with DevOps practices in the cloud, including automation, monitoring, and cost management strategies.
5. Enable to apply the cloud knowledge in real-world scenarios, including migration strategies and full-stack deployment projects.

Week	Theory Topics
1	Introduction to Cloud Computing, Service Models (IaaS, PaaS, SaaS).
2	Cloud Deployment Models & Virtualization Concepts.
3	Cloud Storage & Networking Basics (VPC, Subnets, Load Balancing).
4	Identity & Access Management, Security in the Cloud.
5	Serverless Computing & Containers.
6	Cloud Architecture Design Principles.
7	Introduction to DevOps in the Cloud (CI/CD, Infrastructure as Code).
8	Monitoring, Logging, and Cost Management.
9	Cloud Migration Strategies and Case Studies (AWS, Azure, GCP).
10	Recap, Viva Preparation, and Project Discussions.

Week	Lab Activities
1	Setup Free Tier Cloud Account (AWS/GCP/Azure), Create public & private VPC, Subnets, Security groups, Elastic IP, Launch Virtual Machine.
2	Launch Ec2 [Linux (SSH) | Windows (RDC)] & Config Lamp/Xamp Server to host web applications.
3	Create Scaling activity using Load balancer (Zones & Regions), with Aws Autoscaling to test high availability applications.
4	Create and Configure Object Storage (e.g., AWS S3 or Azure Blob) to test various ACL permissions.
5	Create a Server & Serverless Database (e.g., RDS & MySQL(Ec2) | DynamoDB etc) & List essential connective strings.
6	a. Deploy a Web App using PaaS (e.g., AWS Elastic Beanstalk / App Engine). b. IAM: Create Roles, Policies, and Access Management.

7	Deploy a Serverless Function (AWS Lambda / Azure Function) for specific needs a. Automate Ec2 to Start & Stop for time specific b. Automate S3 deployment with SNS Email Notification to an authorised Email. c. Monitor Resources and Set Alerts (e.g., CloudWatch / Azure Monitor).
8	Cloud Migration Mini Project: Move a Local App to the Cloud.
9	Dockerize and Deploy an App (e.g., ECS / Azure Container Instances).
10	Final Project Presentation.

Course Outcomes

1. Explain fundamental cloud concepts and distinguish between various service and deployment models, as well as basic virtualization principles.
2. Configure and manage cloud storage, virtual private networks, and implement basic access control and security mechanisms.
3. Design and deploy scalable, modular cloud applications using serverless technologies and container-based architectures.
4. Implement automated deployment pipelines, set up monitoring tools, and evaluate cost optimization techniques on a cloud platform.
5. Demonstrate the ability to migrate applications to the cloud and present a working project using appropriate cloud services.

Textbooks / References:

1. Rajkumar Buyya et al., Mastering Cloud Computing, McGraw Hill.
2. Official Docs: AWS, Azure, Google Cloud.
3. Thomas Erl, Cloud Computing: Concepts, Technology & Architecture.

II Semester

SOTT6304	Advanced Machine Learning	L	T	P	C
		2	1	0	3

Course Description:

This course covers advanced machine learning (ML) techniques beyond traditional supervised and unsupervised learning. It includes deep learning, ensemble methods, reinforcement learning, probabilistic models, and generative adversarial networks (GANs). The course emphasizes theoretical foundations, algorithmic implementation, and real-world applications.

Course Objectives:

1. Understand the principles of advanced ML techniques, including deep learning and reinforcement learning.
2. Learn ensemble methods, Bayesian approaches, and probabilistic graphical models.
3. Develop skills to implement ML models using modern frameworks such as TensorFlow and PyTorch.
4. Explore ethical considerations and interpretability of ML models.
5. Apply ML techniques to real-world applications in healthcare, finance, and other domain

UNIT I Advanced Supervised and Unsupervised Learning **9 Hrs**

Advanced Decision Trees and Random Forests-Support Vector Machines (SVM) - Optimization and Kernels- Clustering Techniques (Spectral Clustering, DBSCAN, Gaussian Mixture Models)- Anomaly Detection using ML

UNIT II Deep Learning and Neural Networks **9 Hrs**

Neural Network Architectures (MLP, CNN, RNN)- Backpropagation and Optimization Techniques (Adam, RMSprop)- Autoencoders and Variational Autoencoders (VAE)- Attention Mechanism and Transformers

UNIT III Probabilistic and Bayesian Learning **9 Hrs**

Bayesian Networks and Probabilistic Graphical Models- Hidden Markov Models (HMM) and Gaussian Processes-Markov Chain Monte Carlo (MCMC) Methods- Variational Inference Techniques

UNIT IV Reinforcement Learning and Generative Models **9 Hrs**

Markov Decision Processes (MDP)-Q-Learning and Policy Gradient Methods-Deep Reinforcement Learning (DQN, PPO)-Generative Adversarial Networks (GANs) and Applications.

UNIT V Advanced Topics and Applications **9 Hrs**

Fairness and Bias in Machine Learning-Explainable AI (XAI) and Interpretability Techniques-Scalable ML with Big Data (Spark ML, Federated Learning)-ML Applications in Healthcare, Finance, and Autonomous Systems

Course Outcomes:

After completing this course, students will be able to:

1. Develop and optimize advanced ML models.
2. Implement deep learning architectures such as CNNs, RNNs, and GANs.
3. Apply reinforcement learning techniques for decision-making problems.
4. Analyze large-scale datasets using scalable ML methods.
5. Evaluate and interpret ML models for explainability and fairness.

Text Books & References

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville - *Deep Learning*, MIT Press
2. Kevin P. Murphy - *Machine Learning: A Probabilistic Perspective*, MIT Press
3. Sutton & Barto - *Reinforcement Learning: An Introduction*, MIT Press
4. Christopher Bishop - *Pattern Recognition and Machine Learning*, Springer
5. François Chollet - *Deep Learning with Python*, Manning Publications

MTCT6502	Advanced Computer Networks	L	T	P	C
		2	1	0	3

Course Description:

This course explores the fundamental concepts of computer networks, focusing on network architecture, performance, and the protocols that ensure reliable communication. Topics include switching mechanisms, congestion control, IP addressing (IPv4/IPv6), routing protocols, and network security. Students will also delve into advanced concepts such as multimedia transmission, VoIP, DNS, and the design of data centers and interconnection networks. The course provides hands-on experience with the technologies that support high-speed, reliable, and scalable networks.

Course Objectives:

1. To understand computer network architectures, protocols, and interfaces.
2. The OSI reference model and the Internet architecture network applications.
3. The course will expose students to the concepts of traditional as well as modern day
4. computer networks - wireless and mobile, multimedia-based.
5. Students completing this course will understand the key concepts and practices employed in modern computer networking

UNIT I **9 Hrs**

Network Architecture, Performance: Bandwidth and Latency, High Speed Networks, Network-Centric View, Error Detection, Reliable Transmission, Ethernet and Multiple Access Networks, Overlay Networks: Routing Overlays, Peer-to-Peer Networks and Content Distribution Networks, Client-Server Networks, Delay Tolerant Networks,

UNIT II **9 Hrs**

Switching: Circuit-Switched Networks, Datagram Networks, Virtual-Circuit Networks, Message-Switched Networks, Asynchronous Transfer Mode: Evolution, Benefits, Concepts, Exploring Broadband Integrated Services Digital Network, Layer and Adaptation Layer, IPv4: Address Space, Notations, Classful, Classless, Network Address Translation, Datagram

UNIT III **9 Hrs**

Fragmentation and Checksum IPv6 Addresses: Structure, Address Space, Packet Format and Extension Headers, ICMP, IGMP, ARP, RARP, Congestion Control and Resource Allocation: Problem, Issues, Queuing, TCP Congestion Control, Congestion-Avoidance Mechanisms and Quality of Service.

UNIT IV **9 Hrs**

Internetworking: Intra-Domain and Inter-Domain Routings, Unicast Routing Protocols: RIP, OSPF and BGP, Multicast Routing Protocols: DVMRP, PIM-DM, PIM-SM, CBT, MSDP and MOSPF, Spanning Tree Algorithm, Optical Networking: SONET/SDH Standards, Traffic Engineering: Requirement, Traffic Sizing, Characteristics, Protocols, Time and Delay Considerations, Connectivity, Availability, Reliability and Maintainability and Throughput.

UNIT V **9 Hrs**

Multimedia Over Internet: Transmission, IP Multicasting and VoIP, Domain Name System: Name Space, Domain Name Space, Distribution, Domains, Resolutions and Dynamic

Domain Name System, SNMP, Security: IPSec, SSL/TLS, PGP and Firewalls, Datacenter Design and Interconnection Networks.

Course Outcomes:

After completion of course, students would be:

1. Analyse computer network architectures and estimate quality of service.
2. Design application-level protocols for emerging networks.
3. Analyse TCP and UDP traffic in data networks.
4. Design and analyse medium access methods, routing algorithms and IPv6 protocol for data networks.
5. Analyze Data Center Networks and Optical Networks

Text Books:

1. Larry L. Peterson and Bruce S. Davie, Computer Networks: A System Approach, Fifth Edition, Morgan Kaufmann, Elsevier, 2012.
2. Behrouz A. Forouzan, Data Communications and Networking, McGraw Hill, Fifth Edition, 2017.
3. Chwan-Hwa (John) Wu, J. David Irwin, Introduction to Computer Networks and Cyber Security, CRC press, Taylor & Francis Group,2014.
4. Andrew S. Tanenbaum, David J. Wetherall, Computer Networks, Pearson, 5th Edition, 2014.

Reference Book:

1. Satish Jain Advanced Computer Networking: Concepts and Applications

Program Elective - III

MTCT6603a **Ethical Hacking and Penetration Testing** **L T P C**
3 0 0 3

Course Description:

Ethical Hacking is one of the most popular courses with the increase in people's interest in internet security and ways for keeping one's personal security safe and secure from different peoples. This course cover tools and techniques that are used by hackers and penetration testers and topics in general namely Ethical Hacking, Website, System Hacking & Security and Mobile & Wireless Security.

Course Objectives:

The objective of this course is to make students to,

1. To learn about the importance of information security.
2. To learn different scanning and enumeration methodologies and tools.
3. To understand various hacking techniques and attacks.
4. To be exposed to programming languages for security professionals.
5. To get familiarized with the different phases in penetration testing.

UNIT I **9 Hrs**

Introduction to Hacking: Introduction to Hacking – Importance of Security – Elements of Security – Phases of an Attack – Types of Hacker Attacks – Hacktivism – Vulnerability Research – Introduction to Footprinting – Information Gathering Methodology – Footprinting Tools – WHOIS Tools – DNS Information Tools – Locating the Network Range – Meta Search Engines.

UNIT II **9 Hrs**

Scanning and Enumeration: Introduction to Scanning – Objectives – Scanning Methodology – Tools – Introduction to Enumeration – Enumeration Techniques – Enumeration Procedure – Tools.

UNIT III **9 Hrs**

System Hacking: Introduction – Cracking Passwords – Password Cracking Websites – Password Guessing – Password Cracking Tools – Password Cracking Counter measures – Escalating Privileges –Executing Applications –Keyloggers and Spyware.

UNIT IV **9 Hrs**

Programming for Security Professionals: Programming Fundamentals – C language – HTML – Perl – Windows OS Vulnerabilities – Tools for Identifying Vulnerabilities – Countermeasures – Linux OS Vulnerabilities – Tools for Identifying Vulnerabilities – Countermeasures.

UNIT V

Penetration Testing: Introduction – Security Assessments – Types of Penetration Testing- Phases of Penetration Testing – Tools – Choosing Different Types of Pen-Test Tools – Penetration Testing Tools.

Course Outcomes:

Upon completion of this course, the student should be able to,

1. Understand how to secure the information.
2. Defend hacking attacks and protect data assets.
3. Defend a computer against a variety of security attacks using various tools.
4. Practice and use safe techniques on the World Wide Web.
5. Get familiarized with the different phases in penetration testing.

Text Books:

1. Ec-Council, "Ethical Hacking and Countermeasures: Attack Phases", Delmar Cengage Learning,2009.

2. Michael T. Simpson, Kent Backman, James E. Corley, "Hands-On Ethical Hacking and Network Defense", Cengage Learning, 2012.

Reference Books:

1. Patrick Engebretson, "The Basics of Hacking and Penetration Testing – Ethical Hacking and Penetration Testing Made Easy", Syngress Media, Second Revised Edition, 2013.
2. Jon Erickson, "Hacking: The Art of Exploitation", No Starch Press, Second Edition, 2008.
3. Daniel G. Graham, Ethical Hacking: A Hands-on Introduction to Breaking In, William Pollock, 2021.

MTCT6603b **Digital Forensics** **L T P C**

3 0 0 3

Course Description:

This course explores the field of digital forensics, focusing on the process of investigating computer crimes, collecting, managing, and presenting evidence. Topics include cyber crime scene analysis, forensic methodologies for computers, network and mobile forensics, and the legal aspects of digital investigations. The course covers practical techniques for data retrieval, evidence management, and the use of various forensic tools in the context of criminal investigations and legal requirements.

Course Objectives:

1. To introduce the fundamentals of digital forensics and its relationship to computer crime and criminalistics.
2. To explore methods for cyber crime scene analysis, including search and seizure of electronic evidence and understanding court requirements.
3. To understand evidence management practices, including the forensic mindset, evidence collection, and case preparation.
4. To study computer and network forensics techniques, tools, and processes for investigating and completing a case.
5. To examine mobile forensics, the legal aspects of digital forensics, and the IT Act 2000 and its amendments.

UNIT I **9 Hrs**

Digital Forensics Science: Forensics science, computer forensics, and digital forensics.
Computer Crime: Criminalistics as it relates to the investigative process, analysis of cyber-criminalistics area, holistic approach to cyber-forensics

UNIT II **9 Hrs**

Cyber Crime Scene Analysis: Discuss the various court orders etc., methods to search and seizure electronic evidence, retrieved and un-retrieved communications, Discuss the importance of understanding what court documents would be required for a criminal investigation.

UNIT III **9 Hrs**

Evidence Management & Presentation: Create and manage shared folders using operating system, importance of the forensic mindset, define the workload of law enforcement, Explain what the normal case would look like, Define who should be notified of a crime, parts of gathering evidence, Define and apply probable cause.

UNIT IV **9 Hrs**

Computer Forensics: Prepare a case, Begin an investigation, Understand computer forensics workstations and software, Conduct an investigation, Complete a case, Critique a case.
Network Forensics: open-source security tools for network forensic analysis, requirements for preservation of network data.

UNIT V **9 Hrs**

Mobile Forensics: mobile forensics techniques, mobile forensics tools.
Legal Aspects of Digital Forensics: IT Act 2000, amendment of IT Act 2008.
Recent trends in mobile forensic technique and methods to search and seizure electronic evidence

Course Outcomes:

After completion of course, students would be able to:

1. Understand the principles of digital forensics and its role in cyber-criminalistics.
2. Apply techniques for cyber crime scene analysis and recognize legal requirements for evidence collection.
3. Effectively manage and present evidence in criminal investigations using forensic methodologies.
4. Utilize computer and network forensics tools to conduct investigations and critique forensic cases.
5. Gain expertise in mobile forensics and the legal implications of digital forensics within the context of the IT Act.

Text Books:

1. John Sammons, The Basics of Digital Forensics, Elsevier.
2. John Vacca, Computer Forensics: Computer Crime Scene Investigation, Laxmi Publications

MTCT6603c	Database Security and Privacy	L	T	P	C
		3	0	0	3

Course Description

This course explores the principles and practices of securing modern database systems. Students will understand key threats, vulnerabilities, and attack vectors targeting databases. The course emphasizes access control models, encryption, and privacy-preserving mechanisms essential for secure database design and management. Industry-relevant case studies, including cloud-based and compliance-driven applications, enable students to build secure and privacy-compliant database solutions.

Course Objectives

1. To understand the need for security in database systems and explore common threats and vulnerabilities.
2. To apply access control models, authentication, and authorization mechanisms.
3. To analyze techniques for ensuring data confidentiality, integrity, and availability.
4. To study encryption, auditing, inference control, and privacy-preserving data publishing.
5. To implement best practices for securing modern database platforms including cloud and distributed databases.

UNIT I INTRODUCTION TO DATABASE SECURITY 9 Hrs

Security issues in databases – Database vs OS Security – Types of database threats Models of database security – CIA Triad – Vulnerabilities in SQL – Injection attacks –Threat modelling – Database Security Lifecycle.

Case Study: SQL Injection Attack on a Banking Application

UNIT II ACCESS CONTROL AND AUTHORIZATION MODELS 9 Hrs

User identification and authentication – Access control mechanisms – DAC, MAC, RBAC, and ABAC – View-based access control – Authorization in SQL – Fine-grained access control in Oracle/MySQL.

Case Study: Role-Based Access Control (RBAC) in a University Database

UNIT III DATA ENCRYPTION AND INTEGRITY TECHNIQUES 9 Hrs

Encryption algorithms (AES, RSA) – Transparent Data Encryption (TDE) – Column-level encryption – Hashing and checksums – Digital signatures – Key management – Data masking and tokenization.

Case Study: Implementing TDE in Microsoft SQL Server for Healthcare Records

UNIT IV PRIVACY PRESERVATION AND INFERENCE CONTROL 9 Hrs

Privacy-preserving data publishing – k-Anonymity, l-Diversity, t-Closeness – Statistical database security – Inference detection and prevention – Differential privacy – GDPR and HIPAA compliance in database systems.

Case Study: De-identifying Patient Data for Research (Healthcare Compliance)

UNIT V AUDITING, MONITORING, AND CLOUD DATABASE SECURIT 9 Hrs

Database activity monitoring – Security auditing tools – Log analysis – Triggers and policies – Security in NoSQL databases – Cloud database security – Access control in distributed databases – Security-as-a-Service.

Case Study: Auditing and Monitoring Access Logs in AWS RDS

Course Outcomes

After completing this course, the student will be able to:

1. Analyze database vulnerabilities and threats and apply mitigation techniques.
2. Implement access control and authorization mechanisms in relational and non-relational databases.
3. Apply encryption and data integrity mechanisms for secure storage and transmission.
4. Apply privacy-preserving techniques and comply with data protection regulations.
5. Monitor, audit, and secure database systems in enterprise and cloud environments.

Text Books:

1. Silberschatz, Korth & Sudarshan, *Database System Concepts*, 7th Edition, McGraw-Hill, 2020 (Chapters on Security).
2. Hassan A. Afyouni, *Database Security and Auditing*, Cengage Learning, 2009.

Reference Books:

1. Ron Ben Natan, *Implementing Database Security and Auditing*, Elsevier, 2005.
2. Chun Zhang, *Database Security and Privacy in Computing*, Springer, 2022.
3. Bertino & Sandhu, *Database Security – Concepts, Approaches, and Challenges*, IEEE Transactions.
4. Gertz & Jajodia, *Handbook of Database Security*, Springer.

Program Elective IV

MTCT6604a **Advanced Wireless Sensor Networks** **L T P C**
3 0 0 3

Course Description:

This course provides an in-depth understanding of **Advanced Wireless Sensor Networks (AWSNs)**, covering their architecture, protocols, and applications. Students will gain insights into sensor node design, wireless transmission, MAC and routing protocols, and transport mechanisms specific to WSN environments. The course also addresses middleware solutions, network deployment strategies, and performance optimization. Advanced topics such as **LPWAN integration**, **machine learning-based routing**, **middleware for fog/edge computing**, and **security using blockchain and lightweight cryptography** are introduced to align with current trends in smart systems and IoT ecosystems. Through case studies and research insights, students will develop the ability to design, analyze, and prototype sensor network solutions for complex applications.

Course Objectives:

The primary objective of this course is to introduce the basic principles, techniques, and applications of Artificial Intelligence.

The course should enable the students to:

1. **To introduce** the fundamental concepts, architecture, and applications of Wireless Sensor Networks across various domains.
2. **To examine** the design challenges and trade-offs involved in sensor node technology, wireless communication, and energy efficiency.
3. **To analyze and compare** various MAC, routing, and transport protocols tailored for WSN environments.
4. **To explore** middleware architectures and integration of emerging technologies like edge computing, LPWAN, and IoT frameworks in WSNs.
5. **To evaluate** performance, security, and deployment strategies using modern tools and techniques for real-time and secure sensor network systems.

UNIT I Fundamentals and Emerging Applications of WSNs **9Hrs**

Introduction to Wireless Sensor Networks-Overview of WSN Technology and Architectures-Applications: Category 1 and 2 Applications-Emerging Applications: Smart Cities, Precision Agriculture, Disaster Monitoring-Recent Trends in WSN Design and Deployment-Next-Gen WSNs with Edge AI, Energy Harvesting.

UNIT II Sensor Node Architecture and Wireless Technologies **9Hrs**

Sensor Node Technology and Components-Sensor Taxonomy and System Design-WSN Operating Environments-Wireless Transmission Basics: Modulation, Propagation-Energy-Efficient Communication and Duty Cycling- Integration of LPWAN (LoRa, SigFox, NB-IoT) in WSNs

UNIT III Medium Access and Routing Protocols in WSNs **9 Hrs**

MAC Protocol Fundamentals for WSNs-Contention-based and Schedule-based MACs-Case Studies: Sensor-MAC, IEEE 802.15.4-Routing Challenges in WSNs-Data-Centric and

Geographic Routing- Opportunistic and Reinforcement Learning-Based Routing-6LoWPAN and IPv6 in WSN.

UNIT IV Transport Protocols and Middleware Solutions 9 Hrs

Overview of Traditional Transport Protocols-Transport Protocol Design Constraints in WSNs-Protocols: PSFQ, CODA, RMST, GARUDA-WSN Middleware Design Principles-Middleware Architectures and Services- Fog and Edge Computing Integration with Middleware-Middleware for Real-Time and Mission-Critical WSNs

UNIT V WSN Deployment, Security, and Performance Optimization 9 Hrs

Network Deployment: Static vs Mobile Nodes, Coverage Strategies-Performance Metrics and Optimization Techniques-Security Challenges: Attacks on WSN and Mitigation-Lightweight Cryptography for WSN-Trust Management in Distributed Sensor Environments- Blockchain for Secure WSN Communication-AI/ML for Intrusion Detection in WSNs

Course Outcomes:

After completion of the course, students will be able to

1. Understand and explain the architecture, characteristics, and application domains of Wireless Sensor Networks. (Understanding)
2. Analyze the design space and performance trade-offs in sensor node technologies and wireless communication systems. (Analyzing)
3. Design suitable MAC, routing, and transport protocols for energy-efficient and scalable WSN communication. (Designing)
4. Evaluate middleware solutions and integrate advanced technologies like edge computing and LPWAN into WSN frameworks. (Evaluating)
5. Assess the deployment strategies, security challenges, and performance metrics of WSNs using modern tools and techniques. (Evaluating & Applying

Text Books:

1. **Bagwari, A., Tomar, G. S., Kanti, V., Barbosa, V., & Sastry, K. S.,** Advanced Wireless Communication and Sensor Networks: Applications and Simulations, Routledge, 1st Edition, 2023.
2. **Chatzimisios, P., Verikoukis, C., & Antonopoulos, A.,** *Concepts, Applications, Experimentation and Analysis of Wireless Sensor Networks*, Springer, 3rd Edition, 2023.

References Books:

1. **Kazem Sohraby, Daniel Minoli, and Taieb Znati**, Wireless Sensor Networks: Technology, Protocols, and Applications, Wiley India, 2nd Edition, 2014.
2. **Feng Zhao and Leonidas J. Guibas**, Wireless Sensor Networks: An Information Processing Approach, Elsevier (Morgan Kaufmann Publishers), 1st Edition, 2007.
3. I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A survey on sensor networks," IEEE Communications Magazine, vol. 40, no. 8, pp. 102–114, Aug. 2002. doi: 10.1109/MCOM.2002.1024422.

4. S. Hadim and N. Mohamed, "Middleware for wireless sensor networks: A survey," Journal of Computer Science and Technology, vol. 23, no. 3, pp. 307–320, May 2008. doi: 10.1007/s11390-008-9135-x.
5. K. Christidis and M. Devetsikiotis, "Blockchains and smart contracts for the Internet of Things," IEEE Access, vol. 4, pp. 2292–2303, 2016. doi: 10.1109/ACCESS.2016.2566339.
6. M. Satyanarayanan et al., "A survey on edge computing for the Internet of Things," IEEE Access, vol. 4, pp. 1–1, 2016. doi: 10.1109/ACCESS.2016.2572298.

MTCT6604b	Advanced Wireless Adhoc Networks	L	T	P	C
		3	0	0	3

Course Description:

This course introduces students to the fundamentals and advancements in wireless network technologies, emphasizing the design and functioning of ad hoc and sensor networks. It explores key topics such as MAC and routing protocols, transport and security mechanisms, energy conservation, and Quality of Service (QoS). In addition, the course covers emerging areas like heterogeneous wireless systems including 5G, Cognitive Radio Networks, and IoT-based applications. Students will develop analytical skills and technical knowledge to design, implement, and evaluate advanced wireless systems suitable for real-world deployments.

Course Objectives:

The primary objective of this course is to introduce the basic principles, techniques, and applications of Artificial Intelligence.

The course should enable the students to:

1. Understand the characteristics and challenges of wireless ad hoc networks.
2. Analyze and evaluate MAC and routing protocols suited for infrastructure-less networks.
3. Study multicast and transport mechanisms and explore network security strategies.
4. Examine QoS frameworks and energy-saving techniques in wireless settings.
5. Investigate the role of heterogeneous wireless systems in real-time applications.

UNIT I Introduction to Ad Hoc Wireless Networks and MAC Protocols 9 Hrs

Characteristics and applications of ad hoc wireless networks-Issues and challenges in ad hoc wireless networks-Ad hoc Wireless Internet-MAC Protocols: Design challenges and goals-Classification of MAC Protocols-Contention-Based MAC Protocols-Reservation and Scheduling Mechanisms- MAC Protocols using Directional Antennas

UNIT II Routing in Ad Hoc Wireless Networks 9 Hrs

Routing protocol design challenges-Classification of Routing Protocol-**Table-Driven Routing**: Destination-Sequenced Distance-Vector (DSDV)-Cluster-Head Gateway Switch Routing (CGSR) **On-Demand Routing**: Dynamic Source Routing (DSR)-Ad hoc On-demand Distance Vector (AODV)-Location-Aided Routing (LAR)-Associativity-Based Routing-**Hybrid & Hierarchical Routing**: Zone Routing Protocol (ZRP)-Hierarchical State Routing-Power-Aware Routing Protocols

UNIT III Multicast Routing, Transport & Security Protocols 9 Hrs

Multicast Routing Protocols: Design issues and reference models-Tree-based Protocols: Bandwidth-Efficient Multicast Routing-Preferred Link-Based Multicast Protocol-**SLE**: Mesh-Based Protocols (ODMRP, CAMP)-Transport Layer in Ad hoc Networks: Design goals, TCP variants (TCP-F, Split TCP, TCP-Bus)-Security in Ad hoc Networks: Challenges in security provisioning-Network security attacks – Transport/Application Layer-Key management – Symmetric and Asymmetric- Security-Aware AODV Protocol

UNIT IV Quality of Service and Energy Management in Wireless Networks 9 Hrs

QoS in Ad hoc Networks: Issues, Classification-**MAC Layer QoS Solutions**: IEEE 802.11e, DBASE-**Network Layer QoS Solutions**: Ticket-Based QoS Routing-Bandwidth Routing Protocol-On-Demand QoS Routing Protocol-Energy Management Techniques: Battery and Transmission Management-Power-aware Routing- Case Study on QoS and Energy Efficiency

UNIT V Advanced Topics in Heterogeneous Wireless Networks 9 Hrs

Introduction to Heterogeneous Wireless Networks-Integration of LTE, Wi-Fi, 5G, ZigBee, and Bluetooth-Seamless Handoff, Load Balancing & Interoperability-Cognitive Radio Networks – Architecture and Applications-Software Defined Wireless Networking (SDWN)-Applications: Wireless Sensor Networks in Healthcare, Smart Cities-VANETs and Mobile Social Networks-IoT-based Wireless Applications-Emerging Trends: AI in Wireless, Edge Computing, Federated Learning

Course Outcomes:

After completion of the course, students will be able to

1. Apply fundamental concepts of wireless ad hoc networks to design and analyse network scenarios.
2. Evaluate and compare various MAC and routing protocols for performance and scalability in mobile environments.
3. Design secure and reliable transport mechanisms for wireless networks with constrained infrastructure.
4. Implement QoS provisioning techniques and energy-efficient mechanisms suitable for wireless ad hoc systems.
5. Explore and assess advanced wireless technologies including heterogeneous networks, cognitive radio, and IoT-based applications.

Text Books:

1. **C. Siva Ram Murthy and B. S. Manoj**, Ad Hoc Wireless Networks: Architectures and Protocols, Pearson Education, 2nd Edition, 2011.
2. **Kaveh Pahlavan and Prashant Krishnamurthy**, Principles of Wireless Networks: A Unified Approach, Pearson Education, 1st Edition, 2013.

Reference Books:

1. **David Tse and Pramod Viswanath**, Fundamentals of Wireless Communication, Cambridge University Press, 1st Edition, 2005.
2. **William Stallings**, Wireless Communications & Networks, Pearson Education, 2nd Edition, 2004.
3. **Fouad A. Tobagi**, Wireless Communication Systems: Design and Analysis, Wiley, 1st Edition, 2002.
4. **Jiangzhou Wang**, Wireless Communication Systems: Advanced Topics, Springer, 1st Edition, 2008.
5. **Rappaport, Theodore S.**, Wireless Communications: Principles and Practice, Pearson Education, 2nd Edition, 2002.

MTCT6604c	Quantum Computing	L	T	P	C
		3	0	0	3

Course Description:

This course introduces students to the fundamental concepts of quantum computing, covering essential linear algebra, quantum physics, quantum hardware, and algorithms. The course also delves into quantum architecture, quantum gates, quantum circuits, and quantum entanglement. Students will learn about key quantum algorithms, including Shor's and Grover's algorithms, and explore the impact of quantum computing on current cryptographic methods, including asymmetric encryption algorithms.

Course Objectives:

1. Understand the basics of linear algebra, complex numbers, and set theory, with an emphasis on their applications to quantum computing and mathematical foundations.
2. Gain a solid understanding of the fundamental concepts in quantum physics, including quantum states, entanglement, and key principles of quantum mechanics.
3. Learn about quantum architecture and quantum gates, and understand the hardware requirements, including qubits and decoherence management.
4. Explore quantum algorithms, including Deutsch's, Shor's, and Grover's algorithms, and understand their applications and theoretical importance.
5. Study current asymmetric cryptographic algorithms like RSA and Diffie-Hellman, and analyze the impact of quantum computing on modern cryptography.

UNIT I **9 Hrs**

Introduction to Essential Linear Algebra: Some Basic Algebra, Matrix Math, Vectors and Vector Spaces, Set Theory. Complex Numbers: Definition of Complex Numbers, Algebra of Complex Numbers, Complex Numbers Graphically, Vector Representations of Complex Numbers, Pauli Matrice, Transcendental Numbers.

UNIT II **9 Hrs**

Basic Physics for Quantum Computing: The Journey to Quantum, Quantum Physics Essentials, Basic Atomic Structure, Hilbert Spaces, Uncertainty, Quantum States, Entanglement Basic Quantum Theory: Further with Quantum Mechanics, Quantum Decoherence, Quantum Electrodynamics, Quantum Chromodynamics, Feynman Diagram Quantum Entanglement and QKD, Quantum Entanglement, Interpretation, QKE.

UNIT III **9 Hrs**

Quantum Architecture: Further with Qubits, Quantum Gates, More with Gates, Quantum Circuits, The D-Wave Quantum Architecture.

Quantum Hardware: Qubits, How Many Qubits Are Needed? Addressing Decoherence, Topological Quantum Computing, Quantum Essentials.

UNIT IV **9 Hrs**

Quantum Algorithms: What Is an Algorithm? Deutsch's Algorithm, Deutsch-Jozsa Algorithm, Bernstein-Vazirani Algorithm, Simon's Algorithm, Shor's Algorithm, Grover's Algorithm.

UNIT V **9 Hrs**

Current Asymmetric Algorithms: RSA, Diffie-Hellman, Elliptic Curve The Impact of Quantum Computing on Cryptography: Asymmetric Cryptography, Specific Algorithms, Specific Applications.

Course Outcomes:

At the end of this course the student will be able to,

1. Demonstrate proficiency in the mathematical foundations of quantum computing, including linear algebra and complex numbers.
2. Understand quantum physics principles and the essential components of quantum theory, including entanglement and quantum decoherence.
3. Acquire knowledge of quantum architecture, quantum gates, quantum circuits, and the hardware requirements of quantum computing systems.
4. Develop an understanding of various quantum algorithms and their practical applications in quantum computing.
5. Analyze the impact of quantum computing on asymmetric cryptography and evaluate how quantum algorithms can affect modern cryptographic protocols.

Text Books:

1. Nielsen M. A., Quantum Computation and Quantum Information, Cambridge University Press.
2. Dr. Chuck Easttom, Quantum Computing Fundamentals, Pearson.

Reference Books:

1. Quantum Computing for Computer Scientists by Noson S. Yanofsky and Mirco A. Mannucci.
2. Benenti G., Casati G. and Strini G., Principles of Quantum Computation and Information, Vol. Basic Concepts, Vol.
3. Basic Tools and Special Topics, World Scientific. Pittenger A. O., An Introduction to Quantum Computing Algorithms.

SOTT6305	English for Research Paper Writing	L	T	P	C
		2	0	0	0

Course Description:

This course is designed to help postgraduate students develop essential academic and technical writing skills for effective communication of research. It focuses on the structure and style of scientific writing, including clarity, conciseness, coherence, and correctness. Students will learn how to plan, draft, revise, and finalize various components of a research paper such as abstracts, introductions, literature reviews, methods, results, and conclusions. Emphasis is placed on ethical writing practices, including proper citation and avoiding plagiarism, ultimately guiding students to produce publication-ready manuscripts.

Course Objectives:

By the end of this course, students will be able to:

1. Understand the principles of academic and technical writing specific to research papers.
2. Learn to structure sentences, paragraphs, and sections to achieve clarity and logical flow.
3. Develop skills to write major components of research papers including abstract, introduction, and conclusion.
4. Apply ethical writing practices such as paraphrasing, referencing, and avoiding plagiarism.
5. Enhance their ability to revise and polish manuscripts for effective journal submission.

UNIT I **6 Hrs**

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing, Redundancy, Avoiding Ambiguity and Vagueness

UNIT II **5 Hrs**

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticising, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts.

UNIT III **8 Hrs**

Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check. key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature,

UNIT IV **7 Hrs**

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT V **4 Hrs**

Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission.

Course Outcomes:

After successful completion of the course, students will be able to:

1. Demonstrate the ability to write clearly, concisely, and precisely in academic English.
2. Structure research papers according to scientific conventions with logical flow and coherence.
3. Write each section of a research paper using appropriate academic style and tone.
4. Avoid redundancy, ambiguity, and plagiarism using effective paraphrasing and referencing techniques.
5. Prepare a complete, well-written technical or scientific manuscript ready for submission to academic journals.

Text Books and References:

1. Goldbort R (2006) Writing for Science, Yale University Press.
2. 2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press.
3. 3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman'sbook.
4. 4. Adrian Wallwork, English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011.

SOTL6302	Advanced Machine Learning Lab	L	T	P	C
		0	0	4	2

Course Description:

This lab course provides hands-on experience with advanced machine learning techniques, focusing on deep learning, generative models, and scalable ML frameworks. Students will implement models using TensorFlow, PyTorch, and cloud-based AI services, applying them to real-world datasets in image processing, NLP, and time series forecasting.

Course Objectives:

1. Implement advanced machine learning models using Python and ML libraries.
2. Explore deep learning architectures such as CNNs, RNNs, and Transformers.
3. Work with generative models like GANs and VAEs.
4. Optimize ML models using hyperparameter tuning and transfer learning.
5. Deploy machine learning models on cloud and edge platforms.

Recommended Tools for Advanced Machine Learning Lab

Programming Languages & IDEs

- Python 3.x – Primary language for ML and deep learning
- Jupyter Notebook – Interactive development environment
- Google Colab – Cloud-based notebook with free GPU/TPU access
- PyCharm – IDE for Python development

Deep Learning Frameworks

- TensorFlow 2.x – Deep learning library for training and deploying ML models
- PyTorch – Flexible deep learning framework
- Keras – High-level API for building deep learning models
- ONNX (Open Neural Network Exchange) – Model format for interoperability

Machine Learning & Optimization

- Scikit-learn – Library for machine learning algorithms
- XGBoost / LightGBM – Gradient boosting libraries
- Optuna / Hyperopt – Hyperparameter optimization frameworks

NLP & Computer Vision

- NLTK / spaCy – Libraries for NLP processing
- Transformers (Hugging Face) – Pretrained models for NLP tasks
- OpenCV – Computer vision and image processing library

Data Processing & Visualization

- Pandas / NumPy – Data manipulation libraries
- Matplotlib / Seaborn / Plotly – Data visualization tools

Cloud & Edge AI Deployment

- AWS SageMaker / Google Vertex AI / Azure ML – Cloud ML services
- TensorFlow Lite / OpenVINO – Optimizing ML models for edge deployment

List of Experiments

1: Introduction to Advanced Machine Learning Libraries

- Working with TensorFlow and PyTorch
- Model building, training, and evaluation basics

2: Deep Learning for Image Processing

- Implementing Convolutional Neural Networks (CNNs)
- Transfer Learning with Pretrained Models (ResNet, VGG, EfficientNet)

3: Recurrent Neural Networks and Time Series Analysis

- Implementing RNNs, LSTMs, and GRUs for sequence data
- Forecasting with Transformer-based models (TFT, BERT for Time Series)

4: Natural Language Processing with Deep Learning

- Training custom word embeddings (Word2Vec, FastText)
- Implementing Transformer-based models (BERT, GPT)

5: Generative Models and Unsupervised Learning

- Implementing Variational Autoencoders (VAEs)
- Training Generative Adversarial Networks (GANs)

6: Hyperparameter Optimization and Model Fine-Tuning

- Grid search, Bayesian optimization, and automated ML (AutoML)
- Experimenting with dropout, batch normalization, and learning rate scheduling

7: Scalable Machine Learning with Big Data

- Training ML models on Apache Spark (MLlib)
- Using distributed computing frameworks for large-scale AI

8: Deploying ML Models on Cloud and Edge Devices

- ML model deployment using AWS SageMaker, Google Vertex AI, and Azure ML
- Optimizing models for edge deployment (TensorFlow Lite, OpenVINO)

9: Explainable AI and Model Interpretability

- Visualizing and interpreting ML models (SHAP, LIME)
- Analyzing bias and fairness in AI models

10: Case Study and Project Implementation

- Students work on a real-world project integrating various ML techniques

Course Outcomes:

After completing this course, students will be able to:

1. Develop and train deep learning models for structured and unstructured data.
2. Implement generative models for synthetic data generation.
3. Optimize and fine-tune models for performance and efficiency.
4. Deploy ML models in cloud and IoT environments.
5. Work with scalable ML frameworks for big data processing.

Textbooks & References

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville - Deep Learning, 1st Edition, MIT Press, 2016.
2. François Chollet - Deep Learning with Python, 2nd Edition, Manning Publications, 2021.
3. Aurélien Géron - Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 3rd Edition, O'Reilly Media, 2022.
4. Sebastian Raschka, Vahid Mirjalili - Python Machine Learning, 3rd Edition, Packt Publishing, 2019.

5. Zahid Hossain, Scott Haines - Scalable Machine Learning with Spark, 1st Edition, O’Reilly Media, 2023.

MTCL6501	Advanced Computer Networks Lab	L	T	P	C
		0	0	4	2

Course Description:

This course offers practical knowledge in network programming and protocols through the implementation of client-server applications, network analysis, and various network layers. Students will work with tools like Wireshark for protocol analysis and simulate network topologies for different network scenarios. Topics include queuing management, MAC-layer protocols, routing protocols, and transport-layer protocols. Additionally, students will gain hands-on experience with network security mechanisms, applying these principles to real-world network configurations.

Course Objectives:

1. Understand and implement client-server programs for various network applications.
2. Study and analyze network traffic using Wireshark protocol analyzer.
3. Design and implement network topologies for simulation purposes.
4. Implement queuing management and MAC-layer protocols for network optimization.
5. Apply routing protocols, transport-layer protocols, and network security mechanisms to real-world network configurations.

List of Experiments:

1. Implementation of client server programs for different network applications.
2. Study and analysis of the network using Wireshark network protocol analyser.
3. Implementation of topology generation for network simulation.
4. Implementation of queuing management.
5. Implementation of MAC-layer protocols.
6. Implementation of routing protocols.
7. Implementation of transport-layer protocols.
8. Implementation of network security mechanisms.

Course Outcomes:

1. Ability to develop client-server programs for network communication.
2. Proficiency in using Wireshark to analyze and troubleshoot network protocols.
3. Skills in simulating and managing network topologies and configurations.
4. Understanding of queuing management and MAC-layer protocols for effective network traffic handling.
5. Knowledge of implementing routing protocols, transport-layer protocols, and network security mechanisms to ensure efficient and secure communication.