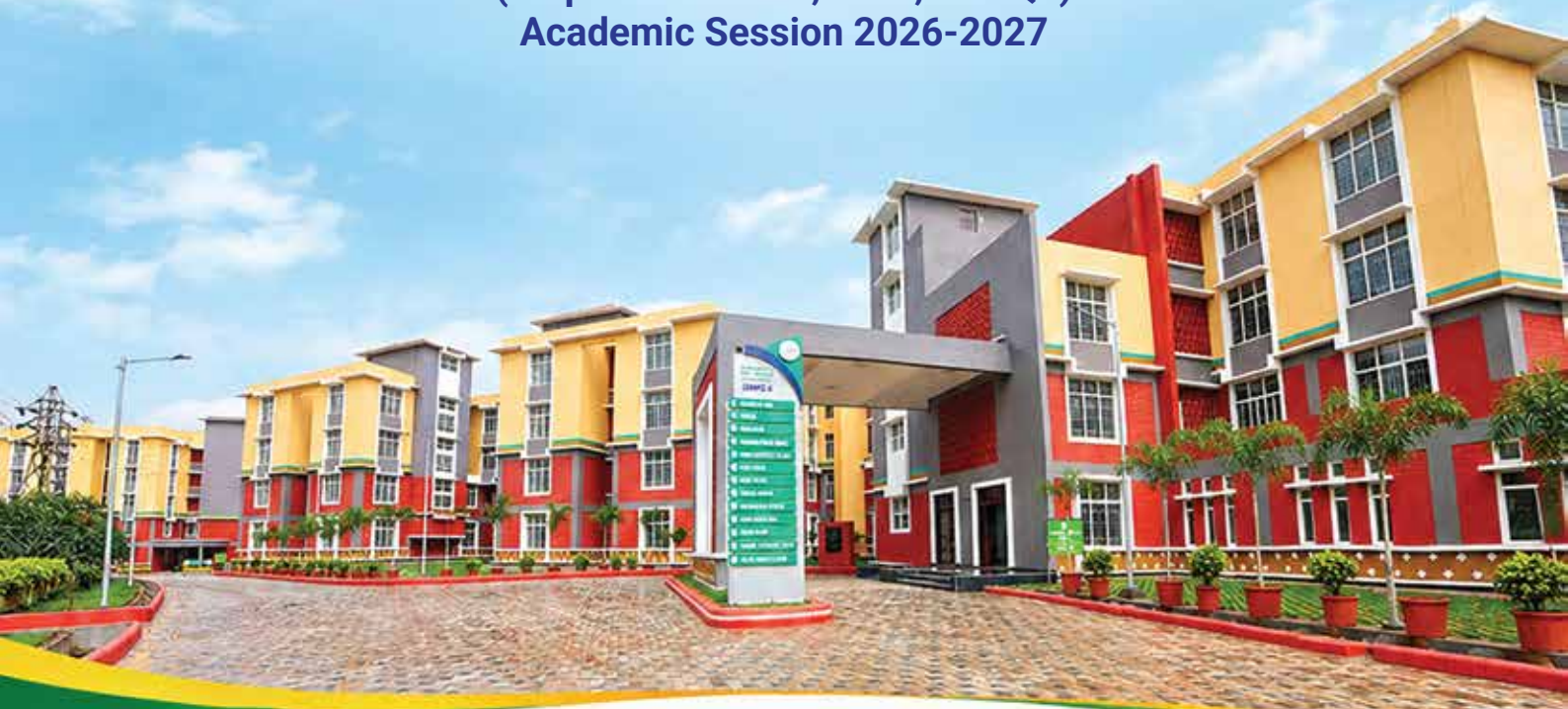
KISS

KALINGA INSTITUTE OF SOCIAL SCIENCES

CURRICULUM AND CREDIT FRAMEWORK FOR POSTGRADUATE PROGRAMME

MASTER OF SCIENCE

(As per NEP-2020, NCrF, NHEQF)
Academic Session 2026-2027



DEPARTMENT OF COMPUTER SCIENCE

SCHOOL OF INDIGENOUS KNOWLEDGE, SCIENCE AND TECHNOLOGY

KALINGA INSTITUTE OF SOCIAL SCIENCES (KISS)

DEEMED TO BE UNIVERSITY

Higher Education Campus, KISS Campus-3, Bhubaneswar, Odisha, 751024
https://university.kiss.ac.in | https://kiss.ac.in

SL. No.		Contents	Pg. No.
I		About the Department / School and Programme	3
	i)	About the School	3
	ii)	About the Department	4
II		Vision & Mission of the School	4
	i)	Vision	4
	ii)	Mission	4
III		Programme Overview	5
	i)	Programme Title	5
	ii)	Programme Type	5
	iii)	Programme Description	5
IV		Process of Curriculum Development	5
V		Definitions of Components	6
VI		NCrF-Aligned Components (National Credit Framework)	6
VII		NCrF-Compliant Course Engagement Table	7
	i)	NCrF Category Wise Credit Distribution (UGC CCFUP Compatible) (for PG Programme)	8
	ii)	Eligibility for Admissions with No. of Seats	8
	iii)	Examination Pattern	8
VIII		Duration and Types of Courses and Process of Multiple Entry and Exit	14
IX		Programme Educational Objectives (PEO)	15
X		Programme Outcomes (PO)	16
XI		Programme Specific Outcomes (PSO)	18
XII		Course Structure of the Postgraduate Programme	18
	i)	Semester - I	20
	ii)	Semester - II	46
	iii)	Semester - III	64
	iv)	Semester - IV	94

I. About the Department / School and Programme

About the School

The School of Indigenous Knowledge, Science and Technology, KISS Deemed to be University, was established in 2017-18 with a view to study Indigenous scientific knowledge and technology that were developed in a symbiotic relationship with Nature. Indigenous people have had an innate understanding of natural resources available in our ecosystem, but it was in a supine state over the years. In the present age of globalization, the tribes who are the custodians of indigenous knowledge and technology in a real sense are far behind in the race of advancement.

Gradual developments of such people in varied facets of life enable them to explore their traditional knowledge for human welfare. As the over-exploitation of natural resources threatens the ecological balance and sustainable livelihood of tribal people, it is imperative to study our time-tested indigenous knowledge and tribal technology with greater vigour. Hence, an innovative School – **School of Indigenous Knowledge, Science and Technology** – has been set up to promote, preserve and protect indigenous knowledge and implement it for sustainable development.

The importance of this School is to disseminate advanced knowledge by providing instructional and research facilities in tribal medicinal systems through phytochemical analysis, geosciences, and their impact on the health conditions. The importance of cosmology in their culture, Sutras and sub-sutras of Vedic mathematics, a nutritional component of the food habit of tribes, intellectual property rights to preserve and conserve the biodiversity of indigenous people and advancement in technologies relating to the natural resources of the tribal areas as well as in other branches of learning as it may deem fit.

This could be possible by teaching innovative courses in *Indigenous Knowledge and Intellectual Property Rights*, *Indigenous People and the Science of Gemmology*, *Indigenous People and the Science of Cosmology* and *Vedic Mathematics*. The courses attempt to examine indigenous knowledge and technology, blending both traditional and modern scientific methods from interdisciplinary and multidisciplinary approaches. The School of Indigenous Knowledge, Science and Technology constantly endeavours to improve the

knowledge and practice content of its academic programme to match the local, regional, national and international standards.

About the Department

The Department of Computer Science at KISS Deemed to be University was established in the academic session 2017–18 with the objective of providing quality computer science education to tribal students through an inclusive and technology-driven learning environment. The department offers postgraduate, postgraduate, and doctoral programmes in Computer Science, following the National Education Policy (NEP) framework and an outcome-based curriculum. The curriculum encompasses programming, data structures, algorithms, database management systems, artificial intelligence, machine learning, data analytics, cloud computing, cyber security, and software engineering, supported by well-equipped computer laboratories and ICT-enabled classrooms. The department is staffed by qualified and experienced faculty members actively engaged in teaching, research, innovation, and interdisciplinary collaborations. Students are encouraged to participate in research projects, coding competitions, seminars, workshops, internships, and community-oriented technological initiatives. With a strong emphasis on academic excellence, ethical values, innovation, and employability, the department prepares graduates to meet the evolving demands of academia, industry, entrepreneurship, and research while contributing to sustainable societal development.

II. Vision & Mission of the School

Vision

Be an internationally acclaimed School, recognized for excellence in teaching, research, consultancy and outreach; skill development and social entrepreneurship for tribal youth by promoting Indigenous Science and Technology.

Mission

- Foster all-around development of students through multi-faceted education.
- Focus on Indigenous Science and Technology with the help of innovative courses like Vedic Mathematics, Indigenous people and the Science of Gemmology, Indigenous Knowledge, and Intellectual Property Rights.

- Engage with local, national, and global communities to get ideas about Indigenous Science and Technological applications for contemporary needs and problems and become successful in life.
- Manage resources self-employment and create employment for others.

III. Programme Overview

Programme Title:

M.Sc. in Computer Science

Programme Type:

Postgraduate / Honours / Honours with Research / Diploma / Certificate

Programme Description

The M.Sc. Computer Science with Specialization in Indigenous Knowledge, Science and Technology is a two-year postgraduate programme designed in alignment with the National Education Policy 2020, the National Credit Framework, the National Higher Education Qualification Framework (Level 8), and the UGC Curriculum and Credit Framework for Postgraduate Programmes (2023). The programme integrates core competencies in computer science with Indigenous Knowledge Systems, preparing students for advanced research, industry roles, entrepreneurship, and community-based innovation. Students develop strong foundations in software engineering, computational mathematics, artificial intelligence, web technologies, cybersecurity, and database systems, while also exploring Indigenous scientific knowledge and its contemporary applications. The curriculum incorporates lectures, case studies, field works, SWAYAM MOOC Courses, and research projects, ensuring a holistic and experiential learning environment consistent with NEP 2020.

IV. Process of Curriculum Development

All Schools shall follow the standard KISS-DU curriculum development protocol:

1. Formation of Syllabus Committee with domain experts.
2. Consultation with stakeholders (students, alumni, employers, community).
3. Review and approval by School faculty.
4. Vetting by Board of Studies (BoS) with external experts.

5. Final approval by Academic Council.
6. Integration of NEP-2020, CBCS, NCrF, and NHEQF guidelines.

V. Definitions of Components

a) Academic Bank of Credits (ABC): The ABC has been envisaged by the UGC to facilitate the academic mobility of students with the freedom to study across the HEIs in the country with an appropriate 'credit transfer' mechanism from one programme to another, leading to attain a Degree/Diploma/Certificate, etc.
b) Academic Year: Two consecutive semesters constitute one academic year.
c) Major is the subject of main focus.
d) Credit Based Semester System (CBSS): Under the CBSS, the requirement for awarding a degree/diploma/Certificate is prescribed in terms of number of credits to be earned.
e) Credit: A unit by which the course work is measured. One credit is equivalent to one hour of lecture or tutorials or two hours of practical work/field work per week in a semester.
f) Research has been provided in the Eighth semester (for students securing 7.5 CGPA or above) involving application of knowledge in exploring/critical analysis/solving issues related to a real-life situation.

VI. NCrF-Aligned Components (National Credit Framework)

1. Operational Definition of Credit (NCrF Standard)

"1 Credit = 30 Notional Learning Hours."

A standard 4-credit course = 120 Notional Learning Hours.

VII. NCrF-Compliant Course Engagement Table

Component	Operational Definition	Hours (Example for 4-credit course)
Face-to-Face Lectures	Concept delivery, interactive instruction	45
Tutorials / Labs / Field	Hands-on practice, experimentation	30
Independent Self-Study	Pre-reading, journal review	20
Continuous Assessment	Assignments, quizzes, mid-term	12
Final Semester Exam Preparation	Revision, project completion	13
Total Notional Hours	**Must equal 30 hours × credits**	**120**

MOOC Courses (SWAYAM and SWAYAM Plus)

According to the UGC guidelines integrated into the new curriculum structures, Higher Education Institutions (HEIs) are permitted to allow students to take up to 40% of their total courses in a semester through the national MOOC platform, SWAYAM (or SWAYAM Plus for industry-aligned courses).

Credits earned via SWAYAM are mapped directly against the appropriate NHEQF academic level and digitally stored in the student's Academic Bank of Credits (ABC) to count toward their final degree, diploma, or certificate.

NCrF Category Wise Credit Distribution (UGC CCFUP Compatible) (for PG Programme)

Semester	Core Courses		IKS		Dissertation		Grand Total Credits
	No. Of Papers	Total Credits	No. Of Papers	Total Credits	No. Of Papers	Total Credits	
I	5	20	1	4			24
II	5	20	1	4			24
III	5	18	1	4			22
IV	-	-			1	20	20
Total Credits for the Course		58		12		20	90

These exit awards correspond to progressive NHEQF / NSQF levels and are fully NCrF-compliant for credit accumulation, mobility and re-entry through the Academic Bank of Credits.

These courses are designed at appropriate NSQF levels, with clear competency descriptors and notional hours.

Eligibility for Admissions with No. of Seats

As per the admission guidelines and brochure of the KISS Deemed to be University.

Examination Pattern:

The medium of examination is English which will be reflected in their final grade sheet/certificate. Provided that for a language subject answers are to be in that language. Sanskrit may be written in Odia script but language has to be Sanskrit.

Duration of the Examinations-Mid Semester & End Semester:

Duration of examination for all term End examination shall be for 2.5 hours and for all Mid Term examination for 1 hour irrespective of full marks in the course/subjects and irrespective of credit. The practical examinations shall be of 2 hours duration.

Each School shall have a designated faculty as Examination Coordinator to be decided by

the Vice Chancellor in addition to the Controller of Examinations of the University.

Continuous Evaluation and Mid Semester Examination:

a) Mid semester examination will be of 1-hour duration for 20/10 marks (20 for subjects having no practical and 10 for subject with practical papers). There shall be no pass mark in Mid Semester examination.

b) The Mid-Semester Examination shall be conducted and valued by the Faculty who are teaching the corresponding paper. A student who fails to appear in a Mid-Semester Examination **will be allowed one more chance to** take the same examination before appearing the concerned term-end examination. There will be no provision to re-appear in the Mid-Semester Examination for improvement.

c) For subjects with practical there will be a Mid-Semester practical examination carrying 10 marks.

d) The University authority of the valuation zones will preserve the answer Script of the End Semester examination for 06 months from the date of publication of result for reference.

e) A student has to appear the mid semester examination positively. Absence in the mid semester examination will be considered as fail however the candidate may be allowed to appear the mid semester examination before commencement of the concerned Term-End examination under special case duly considered by the HoD (for the ***candidates who represent the University or State for Inter- University or inter-state competitions in Games and Sports or attending different recognized National level camps/any critical medical case duly certified by the designated medical officer).***

Distribution of Marks in End Semester and Continuous Evaluation: (Irrespective of credit in a course/Paper)

Course Type	Maximum Marks	Semester-End theory Mark	Continues Evaluation Marks /Sessional	Mid Semester theory Mark	Semester-End and Practical mark	Mid Semester Practical Mark
Without Practical	**100**	**60**	**20**	**20**	**----**	**--**
With Practical	**100**	**50**	**10**	**10**	**20**	**10**
Thesis/ Dissertation/ Seminar/Field Work	**100**	**------**	**-------**	**-------**	**-------**	**-------**

The **modes of evaluation** of **Thesis/ Dissertation/ Seminar/Field Work** shall be as follows:

Literature Review
Synopsis Presentation
Field Work / Data Collection and Data Analysis
Findings and Conclusions
Presentation and Viva-Voce

Distribution of Sessional Marks:(Continuous Evaluation)

Course Type	Maximum Mark	Mid Semester	Attendance	Surprise Test/Quiz/Viva	Assignment/ Presentation
Without Practical	**40**	**20**	**Above 95%- 5 Marks**	**10**	**05**
With Practical	**30**	(Theory 10 + Practical 10)=20	**85%-94%- 4 Marks** **75%-84%- 3 Marks**	**05**	**Nil**

Examination Question Pattern of End Term Examination and Mark Distribution:

The evaluation process may cover summative and formative aspects and assess understanding applications, articulation, program and course outcome.

Question Pattern		**With Practical**	**Without Practical**
Part-I –Objective	**Answer in MCQ/ in one word/in one sentence as directed**	**1x5=5**	**1x6=6**
Part-II- Very Short Type	**Answer within 50 words. Answer any 3 out of 5 questions (with practical) and Answer any 5 out of 7 question (without practical)**	**2x3=6**	**2x5=10**
Part-III- Short Type	**Answer within 250 words Answer any 3 out of 5 questions (with practical) and Answer any 4 out of 6 question (without practical)**	**5x3=15**	**5x4=20**
Part-IV- Long Type	**Answer within 800 words. Answer any 3 out of 5 questions**	**8x3=24**	**8x3=24**
Total		**50**	**60**
For Practical Paper		**One Major Experiment-10 Record- 05 Viva voce-05**	---------

Examination Question Pattern of Mid Semester Examination and Mark Distribution

Question Pattern		With Practical	Without Practical
Part-I –Objective	Answer in MCQ/ in one word/in one sentence as directed	1x3=3	1x6=6
Part-II- Very Short Type	Answer within 50 words. Answer any 1out of 2 questions (with practical) and Answer any 2 out of 3 question (without practical)	2x1=2	2x2=4
Part-III- Short Type	Answer within 250 words Answer any 1 out of 2 questions (with practical) and Answer any 2 out of 3 question (without practical)	5x1=5	5x2=10
Total		10	20
For Practical Paper		One Major Experiment-5 Record- 02 Viva voce-03	--------

Award of Degree:

A Degree certificate under the official seal of the university and signed by the Vice-Chancellor shall be presented at the Convocation or in absentia to each of the successful students of particular degree. The Controller of Examinations shall issue the mark/grade sheet of each semester to the candidates in the sheet of each semester to the candidates in the prescribed format.

VIII. Duration and Types of Courses and Process of Multiple Entry and Exit

NHEQF-Aligned Components (National Higher Education Qualifications Framework)

1. **NHEQF Level Mapping for Multi-Entry / Multi-Exit**

"This programme is structured according to the multi-entry, multi-exit parameters defined by UGC. The progressive qualification bands map directly onto the National Higher Education Qualifications Framework (NHEQF)."

Insert the following table:

Milestone / Year Completed	**Exit Award**	**NHEQF Level**	**Standard Credit Range**
Year 1 (Sem I–II)	Post-Graduate Diploma in Computer Science	Level 6.0	**48 Credits** (Coursework including Core Courses, Electives, Laboratory Courses, Seminar, if applicable)
Year 2 (Sem III–IV)	Master of Science (M.Sc.) in Computer Science	Level 6.5	**90 Credits** (Total) including Advanced Coursework, Project/Dissertation, Seminar, and Research/Industrial Training, where applicable)
	Doctoral Degree	Level 8.0	Credits for coursework and, a thesis and published work

IX. Programme Educational Objectives (PEO)

(Schools may adapt these based on discipline.)

PEO1: Within 2 years of post-graduation, graduates will establish successful careers in industry, academia, government, or the IT sector by applying advanced knowledge of Computer Science, analytical thinking, and problem-solving skills to develop innovative and sustainable computing solutions.

PEO2: Graduates will demonstrate entrepreneurial competence by creating technology-driven products, services, or start-ups, collaborating with industry, and contributing to economic growth through innovation and leadership.

PEO3: Graduates will engage in higher education, research, and lifelong learning by adopting emerging technologies, conducting interdisciplinary research, publishing scholarly work, and pursuing professional certifications to address contemporary challenges

.

PEO4: Graduates will uphold professional ethics, environmental sustainability, inclusiveness, and social responsibility while developing technology-enabled solutions that improve the quality of life and contribute to national and global development.

PEO5: Graduates will integrate indigenous knowledge systems, traditional wisdom, and local community needs with modern computing technologies to develop culturally relevant, sustainable, and socially impactful digital solutions.

X. Programme Outcomes (PO)

(Aligned with NEP-2020 Graduate Attributes)

PO1	Moral & Ethical Values	Apply ethical principles and commit to professional ethics and responsibilities and norms of the software professional practices.
PO2	Disciplinary Knowledge	Acquire and apply the knowledge of mathematics and computer science to solve real life problems.
PO3	Communication Skills	To develop an understanding of, and ability with the different forms of communication - writing, reading, speaking, listening-including visual and graphical, within science and beyond and the ability to apply these appropriately and effectively for different audiences.

PO4	Critical Thinking, Problem solving & analytical reasoning	Acquire an ability to think and work creatively, including the capacity for self-starting, and the ability to apply science skills to unfamiliar applications. It encompasses skills such as understanding risk management and risk-taking, "thinking outside the box", and questioning the norm to suggest new solutions for old problems. Develop an understanding of the scientific method of evidence-based knowledge acquisition, deduction, inference, and induction. Including problem-solving, critical thinking & analysis and the ability to discover new knowledge.
PO5	Indian Knowledge Systems (IKS)	Indian Knowledge Systems (IKS) connects traditional scientific knowledge with modern computing concepts such as algorithms, formal languages, artificial intelligence, and problem-solving techniques. Integrating IKS into computer science education encourages interdisciplinary learning, ethical computing, sustainable technology development, and a deeper understanding of the historical foundations of modern computational methods.
PO6	Research-Related Skills	Use application-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO7	Cooperation/Teamwork	Function effectively as an individual, and as a member or in diverse teams, and in multidisciplinary settings.
PO8	Digital Literacy	Create, select, and apply appropriate techniques, resources, and modern IT tools to model complex solutions with an understanding of their limitations.
PO9	Experiential & Life – long learning	Develop the capacity to engage in reflection and learning beyond formal educational contexts, that is based on the ability to make effective judgments about one's own work and to undertake self-directed, curiosity motivated, learning. The capacity to learn in, and from, new disciplines to enhance the application of scientific knowledge and skills in professional contexts.
PO10	Leadership Qualities	To acquire skills to function as a leader which includes not only subject specific skills such as laboratory skills, computing skills or quantitative data handling skills, but also more generic skills such time management, personal organization, teamwork and negotiation.
PO11	Professional & Decision-making Skills	To acquire, develop, employ, and integrate a range of technical, practical and professional skills, in appropriate and ethical ways within a professional

		context, autonomously and collaboratively and across a range of disciplinary and professional areas.
PO12	Environment Awareness and Sustainability	To build an awareness of the role of science within a global culture and willingness to contribute to the shaping of community views on complex issues where the methods and findings of science are relevant. This includes an understanding of how science underpins society, the applications of science in different cultures and identifying and engaging with current and future challenges.

XI. Programme Specific Outcomes (PSO)

PSO1: Ability to demonstrate a degree of mastery in computer applications through the advanced knowledge of data acquisition, data mining, knowledge discovery and artificial intelligence

PSO2: Ability to independently carry out research/investigation and developmental work to solve practical problems.

PSO3: Develop sound knowledge and skill sets to develop and expand professional careers in fields related to human-computer interaction and management of industrial processes for the design and implementation of intelligent systems.

PSO4: To cater to the demands of the IT and IT-enabled sectors through strong theoretical foundation with high quality teaching complemented with extensive practical training.

XII. Course Structure of the Postgraduate Programme

SEMESTER – I

Paper Code		**Paper Name**	**Credits**			**Credits**
			L	**T**	**P**	
	CS40001	Computer Graphics	3	1	0	4
	CS40003	Python for Computational Science and Artificial Neural Networks	3	0	1	4
Electives	CS40051	Computer Vision and Image Processing	3	0	1	4
	CS40053	Natural Language Processing	3	0	1	4

(Choose ONE Set)		OR				
	CS40055	Big Data Analytics	3	0	1	4
	CS40057	Machine Learning and Deep Learning	3	0	1	4
IK40051		Scientific Research Methods	3	0	1	4
IK40053		Vedic Mathematics	3	1	0	4
Total Credits: 20 + 4 = 24						

SEMESTER – II

Paper Code	**Paper Name**	**Credits**			**Credits**
		L	**T**	**P**	
CS40002	Compiler Design	3	1	0	4
CS40004	Internet of Things	3	1	0	4
CS40006	Blockchain Technologies	3	1	0	4
CS40008	Cloud Computing	3	0	1	4
CS40010	Quantum Computing and Quantum Algorithms	3	0	1	4
IK40052	Indigenous People and the Science of Gemology	3	1	0	4
Total Credits: 20 + 4 = 24					

Students who exit at the end of 1st year shall be awarded a Postgraduate Diploma in Computer Science

SEMESTER – III

Paper Code	**Paper Name**	**Credits**			**Credits**
		L	**T**	**P**	
RM50001	Research Methodology	3	1	0	4
CA50005 (For other Discipline)	Computer Application and Data Analysis	3	0	1	4
CA50007	Data Analysis and Visualization	3	0	1	4
RE50003	Research and Publication Ethics	2	0	0	2
Electives (Choose TWO)					
CS50031	Recommender Systems	3	0	1	4
CS50033	Machine Learning for Predictive Analytics	3	0	1	4
CS50035	Advanced Big Data Systems	3	1	0	4
CS50037	Soft computing	3	0	1	4
IK50051	Indigenous Knowledge and Intellectual Property Rights	3	1	0	4

Total Credits: 18 + 4 = 22

SEMESTER – IV

Paper Code	Paper Name	Credits			Credits
		L	T	P	
RT50082	Research Thesis	0	0	20	20
Total Credits: 20					

Students will be awarded a **PG Computer Science degree** provided they secure 92 credits.

Grand Total Credits = 78 + 12 = 90

*** One Credit = 1 hour for Theory classes (15 hours of lecture/tutorial)**
*** One Credit = 2 hours for Practical classes (30 hrs of practicum)**

Course Structure (Semester-wise)

SEMESTER – I

Paper Code		Paper Name	Credits			Credits
			L	T	P	
CS40001		Computer Graphics	3	1	0	4
CS40003		Python for Computational Science and Artificial Neural Networks	3	0	1	4
Electives (Choose ONE Set)	CS40051	Computer Vision and Image Processing	3	0	1	4
	CS40053	Natural Language Processing	3	0	1	4
		OR				
	CS40055	Big Data Analytics	3	0	1	4
	CS40057	Machine Learning and Deep Learning	3	0	1	4
IK40051		Scientific Research Methods	3	0	1	4
IK40053		Vedic Mathematics	3	1	0	4

Total Credits: 20 + 4 = 24

Course Title: Computer Graphics

Code	Course Title	Credit	L-T-P
CS40001	Computer Graphics	4	3-1-0

Course Objectives:

1. To provide students with advanced knowledge and practical skills in computer graphics
2. Enabling them to design and implement complex graphical applications
3. Critically evaluate and optimize graphical systems.

Course Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of computer graphics, graphics systems, display devices, coordinate systems, and graphical transformations.
- **CO2 (Understanding):** Explain and interpret the principles of line, circle, and polygon generation algorithms, clipping techniques, windowing, viewing transformations, and two-dimensional graphical operations.
- **CO3 (Application):** Apply geometric transformations, clipping algorithms, and projection techniques to develop computer graphics applications using suitable programming tools and graphics libraries.
- **CO4 (Analysis):** Analyze and compare different computer graphics algorithms, rendering techniques, and three-dimensional viewing methods based on computational efficiency, accuracy, and application requirements.
- **CO5 (Synthesis/Evaluation):** Design, implement, and evaluate interactive two-dimensional and three-dimensional computer graphics solutions by integrating transformation, illumination, shading, and rendering techniques to solve real-world visualization problems.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3	PSO4
CO1	3	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-
CO2	-	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO3		3		2	-	-	-	-	-	-	-	-	-	-	2	1
CO4	-	-	-	-	-	-	3	-	-	-	-	-	2	-	-	-
CO5	-	-	-	3	-	-	-	-	-	-	-	-	-	2	-	2

Course Duration: 45 hours

Tutorial: 30 hours

Course Syllabus

Unit 1: Introduction to Computer Graphics [8 Classroom Contact Hours]

Introduction to Computer Graphics, Applications of Computer Graphics, Graphics Hardware and Software, Display Devices, Raster Scan and Random Scan Displays, Input Devices, Frame Buffer, Graphics Software Standards

Unit 2: 3D Modeling and Transformation [8 Classroom Contact Hours]

Coordinate Systems, Translation, Rotation, Scaling, Reflection, Shearing, Homogeneous Coordinates, Composite Transformations, Window-to-Viewport Transformation

Unit 3: Illumination and Shading [9 Classroom Contact Hours]

Light Sources, Reflection Models, Phong Illumination Model, Shading Techniques, Flat Shading, Gouraud Shading, Phong Shading, Introduction to Ray Tracing, Texture Mapping, Basics of Animation, Key Frame Animation

Unit 4: Advanced Rendering Techniques [10 Classroom Contact Hours]

Ray Tracing, Path Tracing, Global Illumination, Radiosity, Physically Based Rendering (PBR), Texture Mapping, Environment Mapping, Shadow Mapping, Bump Mapping, Normal Mapping, Displacement Mapping, Anti-Aliasing Techniques, High Dynamic Range (HDR) Rendering, Real-Time Rendering, GPU-Based Rendering, Rendering Pipeline Optimization.

Unit 5: Graphics Programming and GPU [10 Classroom Contact Hours]

Graphics Programming Fundamentals, OpenGL Programming, OpenGL Graphics Pipeline, Shader Programming, Vertex Shader, Fragment Shader, Geometry Shader, GLSL (OpenGL Shading Language), Buffer Objects, Vertex Array Objects (VAO), Vertex Buffer Objects (VBO), Texture Loading and Mapping, GPU Architecture, GPU Computing Basics, CUDA and OpenCL Overview, Parallel Processing on GPU, Performance Optimization Techniques, Introduction to Vulkan and DirectX

- **Textbook**:

1. "Computer Graphics: Principles and Practice" by John F. Hughes, Andries van Dam, Morgan McGuire, David F. Sklar, James D. Foley, Steven K. Feiner, and Kurt Akeley

- **Reference Books**:

1. "Real-Time Rendering" by Tomas Akenine-Möller, Eric Haines, and Naty Hoffman
2. "Fundamentals of Computer Graphics" by Steve Marschner and Peter Shirley

SWAYAM Course

Computer Graphics - https://onlinecourses.nptel.ac.in/noc24_cs82/preview

SDG Mapping for this Course

SDG	Rationale
SDG 4	High-quality technical education
SDG 9	Innovation in visualization and simulation
SDG 10	Inclusive visual design
SDG 12	Efficient use of computational resources

Course Title: Python for Computational Science and Artificial Neural Networks

Code	Course Title	Credit	L-T-P
CS40003	Python for Computational Science and Artificial Neural Networks	4	3-0-1

Course Objectives:

1. This course equips students with Python programming skills for computational science and introduces the fundamentals of Artificial Neural Networks (ANN).
2. It develops proficiency in scientific computing, numerical methods, data visualization, and neural network modeling, enabling students to solve complex computational problems and build intelligent systems for research and real-world applications

Course Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of Python programming, scientific computing, numerical methods, data structures, and Artificial Neural Networks (ANN).
- **CO2 (Understanding):** Explain and interpret the principles of Python programming, numerical computation, data visualization, optimization techniques, ANN architectures, learning algorithms, and activation functions.
- **CO3 (Application):** Apply Python programming, scientific computing libraries, and ANN models to solve computational problems, analyze datasets, and develop intelligent applications for scientific and engineering domains.
- **CO4 (Analysis):** Analyze computational problems, evaluate the performance of numerical algorithms and neural network models, and compare different optimization and learning techniques for efficient problem solving.
- **CO5 (Synthesis/Evaluation):** Design, implement, and optimize computational science applications and Artificial Neural Network models using Python and appropriate scientific computing libraries to address real-world research and engineering challenges.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	2	-	-	2	-	-	1	-	-	-	1	3	2	-	-
CO2	2	3	1	3	3	-	-	-	-	-	-	-	3	2	-	-
CO3	2	3	3	2	3	1	-	2	-	1	-	-	-	-	3	1

CO4	-	-	2	-	3	1	1	-	2	1	-	-	-	3	3	2
CO5	-	-	-	3	-	2	2	3	-	-	2	-	3	3	-	2

Course Duration: 45 hours

Course Syllabus

UNIT I: Python Programming for Scientific Computing [8 Classroom Contact Hours] Introduction to Python, Python programming environment, variables, data types, operators, input/output, control structures, functions, modules and packages, file handling, exception handling, object-oriented programming concepts, introduction to NumPy arrays, vectorized operations, and scientific computing environment.

UNIT II: Computational Science Using Python [10 Classroom Contact Hours]
Numerical computing fundamentals, mathematical functions using NumPy, matrix operations, linear algebra, solving linear systems, numerical differentiation and integration, interpolation, root-finding methods, optimization basics, random number generation, and introduction to SciPy for scientific computation.

UNIT III: Data Analysis and Visualization [9 Classroom Contact Hours]
Data manipulation using Pandas, importing and exporting datasets, data preprocessing and cleaning, descriptive statistics, data aggregation, visualization using Matplotlib and Seaborn, scientific plotting, histogram, scatter plots, line graphs, bar charts, heat maps, and exploratory data analysis.

UNIT IV: Fundamentals of Artificial Neural Networks [10 Classroom Contact Hours]
Introduction to Artificial Intelligence and Machine Learning, biological neuron and artificial neuron models, perceptron, multilayer perceptron (MLP), activation functions, forward and backward propagation, gradient descent optimization, loss functions, training and testing neural networks, overfitting and underfitting, performance evaluation metrics, and introduction to TensorFlow and Keras.

UNIT V: Advanced Neural Network Applications [8 Classroom Contact Hours]

Introduction to deep learning, Building ANN models: CNN, LeNet, AlexNet, VGG, ResNet, RNN using Keras, hyperparameter tuning, model evaluation, regularization techniques, dropout, batch normalization.

List of Experiments: [30 Lab Contact Hours]

1. Python programming fundamentals and problem-solving.
2. NumPy array creation, indexing, and matrix operations.
3. Scientific computations using SciPy.
4. Numerical methods for solving mathematical problems.
5. Data manipulation and analysis using Pandas.
6. Data visualization using Matplotlib and Seaborn.
7. Implementation of a single-layer perceptron.
8. Design and training of a multilayer neural network using TensorFlow/Keras.
9. Performance evaluation and hyperparameter tuning of ANN models.
10. Mini project involving computational science and ANN applications.

- **Text Books**

1. John V. Guttag, Introduction to Computation and Programming Using Python, 3rd Edition, MIT Press.
2. Eric Matthes, Python Crash Course, 3rd Edition, No Starch Press.
3. Jake VanderPlas, Python Data Science Handbook, 2nd Edition, O'Reilly Media.
4. Charu C. Aggarwal, Neural Networks and Deep Learning, Springer.
5. Simon Haykin, Neural Networks and Learning Machines, 3rd Edition, Pearson.

- **References**

1. Wes McKinney, Python for Data Analysis, 3rd Edition, O'Reilly Media.
2. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 3rd Edition, O'Reilly Media.
3. Sebastian Raschka and Vahid Mirjalili, Machine Learning with PyTorch and Scikit-Learn, Packt Publishing.
4. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning, MIT Press.
5. Steven F. Lott, Mastering Object-Oriented Python, 2nd Edition, Packt Publishing.

SDG Mapping for this Course

SDG	Rationale
SDG 4	Strengthening analytical competencies
SDG 9	Foundations for innovation and intelligent systems
SDG 10	Reducing algorithmic bias
SDG 13	Efficient algorithms reduce energy consumption

Course Title: Computer Vision and Image Processing

Code	Course Title	Credit	L-T-P
CS40051	Computer Vision and Image Processing	4	3-0-1

Course Objectives:

1. This subject emphasis on fundamentals of Image processing and Computer vision.
2. Gain the knowledge of Image Formation, Image Enhancement and Segmentation.
3. Learn various feature extraction techniques.
4. Emphasis on core vision tasks through Motion estimation and Object as well as pattern recognition.
5. Explore the areas where automation can be possible through Image processing and Computer Vision.

Course Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of digital image processing, computer vision, image formation, image representation, color models, and image acquisition techniques.
- **CO2 (Understanding):** Explain and interpret the principles of image enhancement, image restoration, filtering, histogram processing, image transformations, and image formation techniques.
- **CO3 (Application):** Apply image segmentation, feature extraction, feature matching, and computer vision algorithms using appropriate tools and libraries to solve real-world image analysis problems.

- **CO4 (Analysis):** Analyze and compare object detection, object recognition, motion estimation, image segmentation, and feature extraction techniques to develop efficient computer vision solutions.
- **CO5 (Synthesis/Evaluation):** Design, implement, and evaluate image processing and computer vision systems by integrating advanced algorithms, deep learning techniques, and computer vision frameworks to solve real-world applications and support research and innovation.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	3	-	-	-	-	-	-	-	-	-	-	3	1	2	-
CO2	-	-	-	3	2	-	-	-	-	-	-	-	2	1	-	-
CO3	-	3	-	-	-	-	-	-	-	-	-	-	2	2	2	-
CO4	-	-	3	-	-	-	-	-	-	-	-	-	2	2	-	2
CO5	-	-	-	-	-	3	-	-	-	-	-	-	2	3	-	3

Course Duration: 45 hours

Course Syllabus:

Unit 1: Introduction to Image Processing [8 Classroom Contact Hours]

Digital Image fundamentals, Image Sensing and acquisition, Sampling and Quantization, Image formation models, Overview of Computer Vision, Applications of Image processing and Computer Vision

Unit 2: Image enhancement [10 Classroom Contact Hours]

Image Enhancement: Image enhancement in spatial domain, Basic grey level Transformations, Histogram Processing Techniques , Spatial Filtering , Image smoothing and Image Sharpening, Image enhancement process in frequency domain, Low pass filtering, High pass filtering

Unit 3: Image Segmentation [9 Classroom Contact Hours]

Image Segmentation: point, line and edge detection, Thresholding, Regions Based segmentation, Edge linking and boundary detection

Unit 4: Feature Extraction [10 Classroom Contact Hours]

Feature Extraction: Importance of Features, Feature extraction techniques, Histogram of Oriented Gradient (HOG), Scale Invariant Feature Transform (SIFT), Background subtraction techniques, Image Matching

Unit 5: Application of Image Processing [8 Classroom Contact Hours]

Applications of Image Processing and Computer vision, Face Recognition, Facial Expression Recognition, Optical Character Recognition, Automated Video Surveillance

Total Practical / Lab Experiments: [30 Lab Contact Hours]

1. Implement various grey level transformations for Image Enhancement.
2. Implement Histogram Equalization technique.
3. Write a Program to apply convolution processes on an input image for image smoothing.
4. Implement Histogram of Oriented Gradient (HOG) for Feature extraction.
5. Write a Program to apply Scale Invariant Feature Transform on input image.
6. Implement frame differencing technique for background subtraction from video.
7. Implement object detection algorithm YOLO.
8. Implement R-CNN algorithms for object detection.
9. Implement Object recognition.
10. Implement Facial Expression Recognition.

- **Textbook:**

1. **“**Digital Image Processing” by Rafael C. Gonzalez and Richard E. Woods

- **Reference Books:**

1. Digital Image Processing- Refael C. Gonzalez and Richard E. Woods, Wesley
2. Computer Vision - A modern approach, by D. Forsyth and J. Ponce, Prentice Hall Robot Vision, by B. K. P. Horn, McGraw-Hill.
3. Introductory Techniques for 3D Computer Vision, by E. Trucco and A. Verri, Publisher: Prentice Hall.

4. Computer Vision, D. H. Ballard, C. M. Brown, Prentice-Hall, Englewood Cliffs, 1982

SDG Mapping for this Course

SDG	Title	Contribution
SDG 3	Good Health and Well-being	Medical imaging use-cases
SDG 9	Industry, Innovation and Infra	Automation, quality control, robotics
SDG 10	Reduced Inequalities	Critical view of biased vision systems
SDG 13	Climate Action	Vision for climate/land-use monitoring

Natural Language Processing

Code	Course Title	Credit	L-T-P
CS40053	Natural Language Processing	4	3-0-1

Course Objectives:

1. To equip students with the ability to synthesize and apply advanced concepts in Natural Language Processing (NLP) for complex problem-solving.
2. Fostering critical thinking, analytical reasoning, and research-related skills in a multicultural and inclusive technological environment.

Course Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of natural language processing, text preprocessing, linguistic structures, language models, tokenization, and syntax and semantics.
- **CO2 (Understanding):** Explain and interpret the principles of text representation, feature extraction, sequence modeling, word embeddings, machine learning, and deep learning techniques used in natural language processing.
- **CO3 (Application):** Apply NLP techniques, machine learning algorithms, deep learning frameworks, and language processing tools to develop intelligent applications for text classification, sentiment analysis, machine translation,

information retrieval, and question answering.
CO4 (Analysis): Analyze and compare NLP models, language representation techniques, transformer architectures, evaluation metrics, and optimization methods to develop efficient and accurate language processing systems.

- **CO5 (Synthesis/Evaluation):** Design, implement, and evaluate advanced NLP solutions by integrating language models, deep learning techniques, transformer-based architectures, ethical AI principles, and multilingual processing to address real-world language understanding and generation tasks.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	3	-	3	-	-	-	-	-	-	-	-	3	3	2	2
CO2	-	-	-	-	2	3	-	3	-	-	-	-	3	3	2	2
CO3	-	-	-	-	2	-	3	-	-	-	-	-	2	3	-	2
CO4	-	-	3	-	-	-	-	-	-	-	-	3	2	3	2	-
CO5	-	-	-	-	-	-	-	-	3	-	-	-	2	2	-	2

Course Duration: 45 hours

Course Syllabus:

Unit 1: Foundations of NLP [9 Classroom Contact Hours]

Linguistic fundamentals, Text preprocessing and normalization, Language models and word embeddings, Syntax and parsing techniques

Unit 2: Machine Learning for NLP [9 Classroom Contact Hours]

Supervised and unsupervised learning in NLP, Sequence models: RNNs, LSTMs, and GRUs, Attention mechanisms and transformers, Pretrained language models (BERT, GPT)

Unit 3: Semantic Analysis [9 Classroom Contact Hours]

Word sense disambiguation, Semantic role labeling, Coreference resolution, Sentiment analysis and opinion mining

Unit 4: NLP Applications [9 Classroom Contact Hours]

Machine translation, Question answering systems, Information extraction and retrieval, Dialogue systems and chatbots

Unit 5: Emerging Trends and Ethical Considerations [9 Classroom Contact Hours]

Multilingual NLP and low-resource languages, NLP for social media analysis, Bias and fairness in NLP models, Privacy and ethical issues in NLP

Total Practical / Lab Experiments: [22 Lab Contact Hours]

1. Text pre-processing and tokenization
2. Building n-gram language models
3. Implementing a named entity recognition system
4. Creating a sentiment analysis model
5. Developing a chatbot with a sequence-to-sequence model
6. Fine-tuning BERT for text classification
7. Designing a machine translation system
8. Constructing a question answering model
9. Analyzing social media data for trend detection
10. Addressing bias in word embeddings
11. Coreference resolution in documents
12. Semantic role labeling of sentences
13. Information retrieval from a corpus
14. Summarization of news articles
15. Opinion mining from product reviews
16. Multilingual NLP for cross-lingual transfer
17. Privacy-preserving text generation
18. Ethical considerations in NLP applications
19. Implementing attention mechanisms in neural networks
20. Exploring the use of transformers in NLP tasks

- **Textbook:**
  1. "Speech and Language Processing" by Dan Jurafsky and James H. Martin

- **Reference Books:**

1. “Foundations of Statistical Natural Language Processing” by Christopher D. Manning and Hinrich Schütze
2. “Natural Language Processing with PyTorch” by Delip Rao and Brian McMahan

SWAYAM Courses

1. Natural Language Processing - https://onlinecourses.nptel.ac.in/noc24_cs39/preview

SDG Mapping for this Course

SDG	Title	Contribution
SDG 4	Quality Education	Access via translation, summarisation
SDG 5	Gender Equality	Tools to analyse gendered discourse
SDG 10	Reduced Inequalities	Language tech for minority/tribal tongues
SDG 16	Peace, Justice & Institutions	NLP for civic data, hate-speech detection

Big Data Analytics

Code	Course Title	Credit	L-T-P
CS40055	Big Data Analytics	4	3-0-1

Course Objectives:

1. To provide students with a comprehensive understanding of big data analytics, equipping them with the ability to perform complex problem-solving and critical thinking.
2. The course will develop analytical reasoning, research-related skills, and digital literacy, while fostering cooperative teamwork, leadership readiness, and a multicultural competence.
3. Students will enhance their communication skills, gain environmental awareness, and understand the importance of sustainability.
4. The course promotes autonomy, responsibility, accountability, and encourages self-directed learning and lifelong learning.

Course Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of big data, big data analytics, distributed computing, Hadoop ecosystem, data storage, and data processing frameworks.
- **CO2 (Understanding):** Explain and interpret the principles of distributed file systems, MapReduce, Apache Spark, NoSQL databases, data ingestion, and big data analytics techniques.
- **CO3 (Application):** Apply big data technologies, distributed computing frameworks, and analytical tools to process, manage, and analyze large-scale structured and unstructured datasets for real-world applications.
- **CO4 (Analysis):** Analyze and compare big data architectures, processing frameworks, storage technologies, analytics methods, and performance optimization techniques to develop efficient and scalable data-driven solutions.
- **CO5 (Synthesis/Evaluation):** Design, implement, and evaluate scalable big data analytics solutions by integrating distributed computing platforms, advanced analytics techniques, visualization tools, and ethical data management practices to support informed decision-making and sustainable development.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	3	-	3	-	-	-	-	-	-	-	-	2	3	-	3
CO2	-	-	-	-	2	3	-	3	-	-	-	-	-	3	2	2
CO3	-	-	-	-	-	-	3	-	-	3	-	-	-	1	-	-
CO4	-	-	3	-	-	-	-	-	-	-	-	-	2	-	2	3
CO5	-	-	-	-	-	-	-	-	-	-	-	3	2	-	-	3

Course Duration: 45 hours

Course Syllabus:

Unit 1: Foundations of Big Data [8 Classroom Contact Hours]

Introduction to Big Data: Concepts and Characteristics, Big Data Technologies: Hadoop, MapReduce, and Spark, Data Sources and Data Collection Techniques

Unit 2: Big Data Management [10 Classroom Contact Hours]

Data Storage and Processing Architectures, Distributed File Systems and Databases, Data Integration, Cleaning, and Transformation

Unit 3: Big Data Analytics and Mining [10 Classroom Contact Hours]

Descriptive, Predictive, and Prescriptive Analytics, Data Mining Techniques and Algorithms, Real-time Analytics and Stream Processing

Unit 4: Machine Learning for Big Data [8 Classroom Contact Hours]

Supervised and Unsupervised Learning, Scalable Machine Learning Algorithms, Deep Learning and Neural Networks for Big Data

Unit 5: Ethical and Legal Aspects of Big Data [9 Classroom Contact Hours]

Data Privacy and Security Challenges, Ethical Implications of Big Data, Regulatory Compliance and Data Governance

Total Practical / Lab Experiments: [30 Lab Contact Hours]

1. Setting up a Hadoop cluster
2. Implementing MapReduce jobs
3. Building Spark applications
4. Data cleaning and preprocessing
5. Designing a NoSQL database schema
6. Integrating heterogeneous data sources
7. Conducting exploratory data analysis
8. Developing predictive models with machine learning
9. Real-time data stream processing
10. Neural network implementation for large datasets
11. Visualization of big data insights
12. Ethical case studies in big data

13. Security measures for big data storage
14. Compliance audit for data governance
15. Big data project management simulation
16. Collaborative data science project
17. Workshop on communication of data analytics
18. Environmental impact assessment of big data projects
19. Self-directed research on a big data topic
20. Capstone project integrating multiple aspects of big data analytics

- **Textbook:**
  1. "Big Data: Principles and Best Practices of Scalable Realtime Data Systems" by Nathan Marz and James Warren

- **Reference Books:**
  1. "Data-Intensive Text Processing with MapReduce" by Jimmy Lin and Chris Dyer
  2. "Learning Spark: Lightning-Fast Big Data Analysis" by Holden Karau, Andy Konwinski, Patrick Wendell, and Matei Zaharia
  3. "Hadoop: The Definitive Guide" by Tom White

SWAYAM Courses

1. Big Data Computing - https://onlinecourses.nptel.ac.in/noc24_cs130/preview

SDG Mapping for this Course

SDG	Title	Contribution
SDG 3	Good Health and Well-being	Health and epidemic big-data
SDG 4	Quality Education	High-end analytics competence
SDG 9	Industry, Innovation and Infra	Data-driven innovation at scale
SDG 10	Reduced Inequalities	Macro-level inequality analysis
SDFG 13	Climate Action	Climate / energy large-scale analytics

Course Title: Machine Learning and Deep Learning

Code	Course Title	Credit	L-T-P

CS40057	Machine Learning and Deep Learning	4	3-0-1

Course Objectives:

1. To provide students with a comprehensive understanding of machine learning and deep learning.
2. Enabling them to develop solutions for complex problems, think critically about data.
3. Engage in research with a spirit of teamwork and inclusivity.

Course Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of deep learning, artificial neural networks, perceptrons, activation functions, learning algorithms, and deep neural network architectures.
- **CO2 (Understanding):** Explain and interpret the principles of feedforward neural networks, convolutional neural networks (CNNs), recurrent neural networks (RNNs), long short-term memory (LSTM) networks, transformers, optimization techniques, and model evaluation methods.
- **CO3 (Application):** Apply deep learning algorithms, neural network frameworks, and optimization techniques to design, train, and implement intelligent models for image processing, natural language processing, speech recognition, and other real-world applications.
- **CO4 (Analysis):** Analyze and compare deep learning architectures, optimization algorithms, loss functions, regularization methods, transfer learning techniques, and performance evaluation metrics to develop efficient and accurate predictive models.
- **CO5 (Synthesis/Evaluation):** Design, implement, and evaluate advanced deep learning solutions by integrating appropriate neural network architectures, optimization strategies, transfer learning, explainable AI, and ethical AI practices to address complex real-world problems across diverse domains.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PSO	PSO	PSO	PSO

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	3	3	-	3	-	-	-	-	-	-	-	-	3	3	2	2
CO2	-	-	-	-	2	3	-	3	-	-	-	-	3	3	2	2
CO3	-	-	-	-	3	-	3	-	-	-	-	-	2	2	2	2
CO4	-	-	3	-	-	-	-	-	-	-	-	3	3	2	2	3
CO5	-	-	-	-	-	-	-	-	3	-	-	-	2	2	2	3

Course Duration: 60 hours

Course Syllabus:

Unit 1: Introduction to Machine learning [9 Classroom Contact Hours]

Fundamentals of machine learning, Machine learning process, Types of machine learning with example, Overview of data, collection of data

Unit 2: Deep Learning Architectures [12 Classroom Contact Hours]

Convolutional Neural Networks (CNNs),Recurrent Neural Networks (RNNs), Long Short-Term Memory (LSTM) networks, Autoencoders and Generative Adversarial Networks (GANs)

Unit 3: Optimization and Regularization Techniques [6 Classroom Contact Hours]

Advanced optimization algorithms, Regularization methods, Hyperparameter tuning, Model evaluation and validation

Unit 4: Applications of Neural Networks [9 Classroom Contact Hours]

Image and speech recognition, Natural language processing, Reinforcement learning, Neural networks in industry

Unit 5: Current Trends and Ethical Considerations [9 Classroom Contact Hours]

Transfer learning and few-shot learning, Interpretability and explainability of models, Ethical implications of AI, Future directions in neural networks and deep learning

Total Practical / Lab Experiments: [30 Lab Contact Hours]

1. Implementing a perceptron from scratch
2. Training a CNN for image classification
3. Using RNNs for time series prediction

4. Building an LSTM for text generation
5. Creating a GAN for image generation
6. Applying transfer learning to a new dataset
7. Optimizing neural networks with advanced algorithms
8. Regularizing models to prevent overfitting
9. Tuning hyperparameters for better model performance
10. Validating models using cross-validation techniques
11. Developing a speech recognition system
12. Processing natural language for sentiment analysis
13. Designing a reinforcement learning agent
14. Analyzing the impact of AI in healthcare
15. Exploring the interpretability of neural networks
16. Discussing the ethical considerations of AI deployment
17. Investigating the role of AI in environmental sustainability
18. Engaging in self-directed learning to explore a new deep learning library
19. Collaborating on a team project to solve a real-world problem using neural networks
20. Presenting a research proposal on a novel application of deep learning

- **Textbook:**
  1. "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville

- **Reference Books:**
  1. "Neural Networks and Deep Learning: A Textbook" by Charu C. Aggarwal
  2. "Pattern Recognition and Machine Learning" by Christopher M. Bishop

SWAYAM Courses

Deep Learning - IIT Ropar - https://onlinecourses.nptel.ac.in/noc24_cs114/preview

SDG Mapping for this Course

SDG	Title	Contribution
SDG 3	Good Health and Well-being	Predictive models in health
SDG 4	Quality Education	Advanced analytical skill-building
SDG 9	Industry, Innovation and Infra	Intelligent systems development
SDG 10	Reduced Inequalities	Models for inclusion, risk of bias focus

SDG 13	Climate Action	Climate/agri prediction models

Course Title: Scientific Research Methods

Code	Course Title	Credit	L-T-P
IK40051	Scientific Research Methods	4	3-0-1

Course Objectives:

This course introduces students to the principles and methodologies of scientific research. It develops skills in research design, literature review, hypothesis formulation, data collection, statistical analysis, ethical research practices, scientific writing, and publication, enabling students to conduct independent, rigorous, and high-quality research in interdisciplinary scientific and technological domains.

Course Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of scientific research, research methodologies, research ethics, literature review, hypothesis formulation, research design, and data collection techniques.
- **CO2 (Understanding):** Explain and interpret the principles of qualitative and quantitative research methods, sampling techniques, statistical analysis, experimental design, research ethics, intellectual property rights, and scholarly communication.
- **CO3 (Application):** Apply appropriate research methodologies, statistical tools, and data analysis techniques to formulate research problems, conduct scientific investigations, and interpret research findings.
- **CO4 (Analysis):** Analyze research literature, evaluate experimental results, assess the validity and reliability of data, and critically examine scientific findings using appropriate analytical and statistical methods.
- **CO5 (Synthesis/Evaluation):** Design and conduct independent research by integrating scientific methodologies, ethical practices, statistical analysis, and academic writing skills to prepare research proposals, technical reports, dissertations, and research publications.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	2	–	2	2	3	1	–	2	2	3	2	1	–	2	2
CO2	–	2	–	3	–	3	–	3	2	–	2	–	3	–	3	1
CO3	1	3	2	3	1	3	1	2	2	–	2	–	2	1	3	2
CO4	–	2	3	2	–	2	1	3	2	–	2	–	2	–	2	2
CO5	3	2	2	2	2	3	–	1	2	2	3	1	1	–	2	2

Course Duration: 45 hours

Course Syllabus:

Unit 1: Scope of Research [5 Classroom Contact Hours]

Introduction, overview of research process: define research problem, review literature, formulate hypothesis, design research/experiment, collect and analyse data, interpret and report, scope and importance.

Unit 2: Literature Survey, Databases and Research metrics [15 Classroom Contact Hours]

Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, Digital: Databases and their responsible use: Google Scholar, Web of science, Scopus, UGC INFONET, SciFinder, PubMed, ResearchGate, E-consortium, e-books; Search techniques: Phrase, Field, Boolean, Proximity, Concept, Limiting/Refining Search Results. Research metrics: Impact factor of Journal, h-index, i10 index, Altmetrics, Citation index. Author identifiers/or profiles: ORCID, Publons, Google Scholar, ResearchGate, VIDWAN.

Unit 3: Communication in Science [13 Classroom Contact Hours]

Types of technical documents: Full length research paper, book chapters, reviews, short communication, project proposal, Letters to editor, and thesis. Thesis writing – different steps and software tools (Word processing, LaTeX, Chemdraw, Chemsketch etc) in the design and preparation of thesis, layout, structure (chapter plan) and language of typical reports, Illustrations and tables, bibliography, referencing: Styles (APA, Oxford etc), annotated bibliography, Citation management tools: Mendeley, Zotero and Endnote; footnotes. Oral presentation/posters – planning, software tools, creating and making effective presentation, use of visual aids, importance of effective communication, electronic manuscript submission, effective oral scientific communication and presentation skills.

Unit 4: Ethical Practices in Research and Publication [12 Classroom Contact Hours]

Scientific Conduct: Ethics with respect to science and research, Scientific Misconducts: falsification, fabrication and plagiarism, similarity index, software tools for finding plagiarism (Turnitin, Urkund etc), redundant dublications Publication Ethics: Introduction, COPE (Committee on Publication Ethics) guidelines; conflicts of interest, publication misconduct: problems that lead to unethical behaviour and vice versa, types, violation of publication ethics, authorship and contributorship, predatory publishers and journals IPR - Intellectual property rights and patent law, commercialization, copy right, royalty, trade related aspects of intellectual property rights (TRIPS).

Total Practical / Lab Experiments: [30 Lab Contact Hours]

1. Collection of journal articles on a particular topic using Google Scholar and creating a database.
2. Collection of journal articles on a particular topic using Science Direct and creating a database.
3. Collection of journal articles on a particular topic using Scopus and creating a database.
2. Drawing chemical structure, reactions and mechanisms using Chemsketch or ISIS draw or any other software.
3. Collection of chemical structure using ChemSpider and creating a database.
4. Curve fitting using freely available softwares/apps (any one)
5. Making of power point presentation
6. Technical writing on topics assigned.
7. Demonstration for checking of plagiarism using recommended software

- **Reference Book:**

1. Kothari, C. R. & Garg, G. (2019). *Research Methodology: Methods and Techniques* (4th Edition). New Age International Publishers, New Delhi.
2. Day, R. A. & Gastel, B. (2024). *How to Write and Publish a Scientific Paper* (9th Edition). Cambridge University Press..
3. Gopalakrishnan, S. (2019). *Patent Law and Intellectual Property*. Eastern Book Company, Lucknow.
4. Bird, A. (2020). *Understanding Scientific Method*. Routledge, London..

5. Wallwork, A. (2020). *English for Writing Research Papers* (2nd Edition). Springer Nature, Cham.
6. Resnik, D. B. (2020). *The Ethics of Research with Human Subjects: Protecting People, Advancing Science, Promoting Trust*. Springer Nature, Cham.

SWAYAM Course

Research Methodology - https://onlinecourses.nptel.ac.in/noc24_ge41/preview

SDG Mapping for this Course

SDG No.	SDG Title	Rationale
SDG 4	Quality Education	Strengthens research skills, ethical awareness and scientific communication for higher education
SDG 9	Industry, Innovation & Infrastructure	Supports innovation through responsible research, data analysis and publication practices
SDG 16	Peace, Justice & Strong Institutions	Encourages integrity, transparency, accountability and trust in scientific research

Course Title: Vedic Mathematics

Code	Course Title	Credit	L-T-P
IK40053	Vedic Mathematics	4	3-1-0

Course Objectives:

1. To provide students with the skills and knowledge to use Python for solving complex computational problems in science and engineering.
2. Fostering critical thinking, analytical reasoning, and collaborative skills.

Course Learning Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of Vedic Mathematics, its historical development, major Sutras, Sub-Sutras, and their applications in mathematical computations.
- **CO2 (Understanding):** Explain and interpret the principles of arithmetic operations, simple equations, arithmetic progression, and computational techniques based on Vedic Mathematics.

- **CO3 (Application):** Apply Vedic Mathematics techniques, including factorization, HCF, partial fractions, and differential calculus, to solve mathematical problems using appropriate Sutras and Sub-Sutras.
- **CO4 (Analysis):** Analyze and compare conventional mathematical methods with Vedic Mathematics techniques to evaluate their efficiency, accuracy, and applicability in solving computational problems.
- **CO5 (Synthesis/Evaluation):** Evaluate the significance of ethnomathematics, indigenous mathematical knowledge systems, numerals, and naming systems, and assess their relevance in modern mathematics and interdisciplinary applications.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
CO2	-	3	-	-	-	-	-	-	-	-	-	-	2	-	-	-
CO3	-	3	-	2	3	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	-	-	-	-	3	-	-	-	-	-	-	2	-	-
CO5	-	-	-	3	-	-	-	-	-	-	-	-	-	2	-	1

Course Duration: 45 hours

Tutorial: 30 hours

Course Syllabus

Unit-I: Introduction to Mathematics in Vedas [11 Classroom Contact Hours]

Introduction to Mathematics in Vedas, different sutras and sub sutras, examples of sutras and sub sutras, Basic Concepts of Ancient Arithmetic, development and their uses, Different operations in Vedic mathematics: Addition, subtraction, multiplication, division, square, square root, cube and cube root and Examples.

Unit – II: Knowledge on Arithmetic progression [12 Classroom Contact Hours]

Knowledge on Arithmetic progression in Ancient India and different techniques, Simple equations, quadratic equations, Cubic equation, biquadrate equation, Simultaneous equation in Vedic mathematics.

Unit – III: Mathematical numbers in Indian Tradition [12 Classroom Contact Hours]

Mathematical numbers in Indian Tradition and different types of problems relating to Vedic sutras, Factorization, H.C.F, Partial fractions, Differential calculus in Vedic mathematics.

Unit – IV: Mathematical Concept in Tribal Tradition [10 Classroom Contact Hours]

Ethno mathematics: development and meaning of "ethno mathematics", Numerals and naming systems, Mathematics in folk art, Informal mathematics. Pythagoras theorem, Integration by partial fractions, Apollonius theorem, Analytical geometry in Vedic mathematics.

- **Textbook**:

1. Vedic Mathematics space book by S,.JK. Cosmic Kapoor- 2005
2. Vedic Arithmetic and Development of basic concepts Dr. K.P. Chamola – 2006 Arithmetic

Note: Latest edition of the text books should be used.

SDG Mapping for this Course

SDG	Rationale
SDG 4	Strengthening foundational numeracy
SDG 10	Promoting equity through accessible methods
SDG 11	Preserving cultural heritage
SDG 17	Knowledge partnerships and cultural exchange

SEMESTER – II

Paper Code	Paper Name	Credits			Credits
		L	T	P	
CS40002	Compiler Design	3	1	0	4
CS40004	Internet of Things	3	1	0	4
CS40006	Blockchain Technologies	3	1	0	4
CS40008	Cloud Computing	3	0	1	4
CS40010	Quantum Computing and Quantum Algorithms	3	0	1	4
IK40052	Indigenous People and the Science of Gemology	3	1	0	4
Total Credits: 20 + 4 = 24					

Course Title: Compiler Design

Code	Course Title	Credit	L-T-P
CS40002	Compiler Design	4	3-1-0

Course Objectives:

1. To provide students with an in-depth understanding of compiler construction
2. Enabling them to design and analyze compilers that efficiently translate high-level programming languages into machine code
3. Fostering complex problem-solving and critical thinking skills.

Course Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of compiler design, language processors, lexical analysis, syntax analysis, semantic analysis, and compiler phases.
- **CO2 (Understanding):** Explain and interpret the principles of lexical analysis, parsing techniques, syntax-directed translation, symbol table management, and error handling in compiler construction.
- **CO3 (Application):** Apply compiler construction techniques to develop lexical analyzers, parsers, intermediate code generators, and runtime environments using appropriate tools and programming languages.
- **CO4 (Analysis):** Analyze and compare parsing methods, code optimization techniques, runtime environments, and code generation strategies to improve compiler efficiency and performance.

- **CO5 (Synthesis/Evaluation):** Design, implement, and evaluate compiler components by integrating lexical analysis, syntax analysis, semantic analysis, code optimization, and code generation techniques for programming language translation.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-
CO2	-	3	-	-	3	-	-	-	-	-	-	-	-	2	-	-
CO3	-	3	-	-	3	-	-	-	-	-	-	-	-	3	-	2

CO4	-	-	3	-	-	-	-	-	-	-	-	-	3	2	-	-
CO5	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	2

Course Duration: 45 hours

Tutorial: 30 hours

Course Syllabus:

Unit 1: Introduction to Compiler Design [8 Classroom Contact Hours]

Introduction to Compiler Design, Language Processing System, Compiler Structure, Phases of a Compiler, Lexical Analysis, Tokens, Patterns and Lexemes, Finite Automata, Regular Expressions, Lexical Analyzer Generation, Symbol Table Management, Error Handling, Introduction to Compiler Construction Tools.

Unit 2: Syntax-Directed Translation [10 Classroom Contact Hours]

Context-Free Grammars (CFG), Parse Trees, Ambiguity in Grammars, Syntax Analysis, Top-Down Parsing, Recursive Descent Parsing, Predictive Parsing (LL(1)), Bottom-Up Parsing, Shift-Reduce Parsing, LR Parsing, Syntax-Directed Definitions (SDD), Syntax-Directed Translation Schemes (SDT), Intermediate Code Generation, Abstract Syntax Trees.

Unit 3: Type Checking and Runtime Environments [9 Classroom Contact Hours]

Type Systems, Type Checking, Type Conversion and Coercion, Type Expressions, Scope and Binding of Names, Symbol Table Organization, Storage Organization, Runtime Memory Management, Activation Records, Parameter Passing Mechanisms, Procedure Calls, Stack and Heap Allocation, Garbage Collection, Runtime Environments.

Unit 4: Code Optimization [9 Classroom Contact Hours]

Introduction to Code Optimization, Basic Blocks and Flow Graphs, Directed Acyclic Graph (DAG) Representation, Common Subexpression Elimination, Constant Folding, Constant Propagation, Copy Propagation, Dead Code Elimination, Loop Optimization, Peephole Optimization, Data Flow Analysis, Local and Global Optimization Techniques.

Unit 5: Code Generation and Linking [9 Classroom Contact Hours]

Code Generation Principles, Target Machine Architecture, Register Allocation and Assignment, Instruction Selection, Code Scheduling, Machine-Dependent Optimization,

Object Code Generation, Linking and Loading, Static and Dynamic Linking, Relocation, Assembly Process, Compiler Testing and Debugging, Introduction to Just-In-Time (JIT) Compilation.

Total Practical / Lab Experiments: [30 Lab Contact Hours]

1. Implement a lexer for a subset of a programming language.
2. Develop a parser for simple expressions and statements.
3. Write a syntax-directed translator to generate intermediate code.
4. Create a type checker for a statically-typed language.
5. Implement a basic block and flow graph for a function.
6. Develop optimization passes for constant propagation.
7. Write a register allocator using graph coloring.
8. Implement instruction selection for a simple architecture.
9. Create a linker to combine multiple object files.
10. Analyze the impact of different code optimizations on performance.

- **Textbook**:
  1. Compilers: Principles, Techniques, and Tools" by Alfred V. Aho, Monica S. Lam, Ravi Sethi, and Jeffrey D. Ullman
- **Reference Books**:
  1. "Engineering a Compiler" by Keith D. Cooper and Linda Torczon
  2. "Modern Compiler Implementation in C" by Andrew W. Appel

SWAYAM Courses

Compiler Design - https://onlinecourses.nptel.ac.in/noc24_cs18/preview

SDG Mapping for this Course

SDG	Rationale
SDG 4	Strengthens advanced computing education
SDG 9	Supports innovation in programming languages and systems
SDG 12	Efficient compilation contributes to sustainable computing

Course Title: Internet of Things

Code	Course Title	Credit	L-T-P
CS40004	Internet of Things	4	3-1-0

Course Objectives:

1. To provide students with a comprehensive understanding of the Internet of Things (IoT) ecosystem, including its architecture, technologies, and applications,
2. Eabling them to design and implement IoT solutions that address complex problems and contribute to sustainable development.

Course Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of the Internet of Things (IoT), IoT architecture, sensors, actuators, communication technologies, and IoT ecosystem.
- **CO2 (Understanding):** Explain and interpret the principles of IoT communication protocols, embedded systems, cloud integration, data acquisition, and security mechanisms in IoT environments.
- **CO3 (Application):** Apply IoT hardware platforms, communication protocols, and software tools to design, develop, and implement smart IoT-based applications for real-world problems.
- **CO4 (Analysis):** Analyze and compare IoT architectures, communication protocols, data management techniques, and security models to identify appropriate solutions for diverse application domains.
- **CO5 (Synthesis/Evaluation):** Design, implement, and evaluate secure, scalable, and sustainable IoT solutions by integrating sensors, embedded systems, cloud services, and data analytics to address industrial and societal challenges.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	P O	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4

					5											
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	3	2	-
CO2	-	3	-	-	1	-	-	-	-	-	-	-	-	3	-	2
CO3	-	3	-	-	-	-	-	-	-	-	-	-	2	-	-	-
CO4	-	-	3	-	-	-	2	-	-	-	-	-	-	2	-	-
CO5	-	-	3	-	-	-	-	-	2	-	-	-	2	-	-	2

Course Duration: 45 hours

Tutorial: 30 hours

Course Syllabus:

Unit 1: Introduction to IoT [9 Classroom Contact Hours]

Overview of IoT and its significance, IoT architecture and design principles, Sensors, actuators, and smart objects

Unit 2: IoT Communication Technologies [9 Classroom Contact Hours]

Wired and wireless communication protocols, Networking for IoT: LAN, PAN, and mesh networks, IoT standards and ecosystems

Unit 3: IoT Data Management and Analytics [9 Classroom Contact Hours]

Data acquisition, preprocessing, and storage, Big data analytics in IoT, Cloud computing and IoT integration

Unit 4: IoT Security and Privacy [9 Classroom Contact Hours]

Security challenges in IoT, Privacy concerns and data protection, Secure IoT design and best practices

Unit 5: IoT Applications and Future Trends [9 Classroom Contact Hours]

Smart cities, homes, and grids, Industrial IoT and automation, Future trends and challenges in IoT

- **Textbook**:

1. Internet of Things: Principles and Paradigms" edited by Rajkumar Buyya and Amir Vahid Dastjerdi.

- **Reference Books**:

1. "Internet of Things: A Hands-On Approach" by Arshdeep Bahga and Vijay Madisetti
2. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases" by Pethuru Raj.

SWAYAM Course

Introduction to Internet of Things - https://onlinecourses.nptel.ac.in/noc24_cs115/preview

SDG Mapping for this Course

SDG	Rationale
SDG 3	IoT in health monitoring
SDG 9	Smart infrastructure
SDG 11	Smart cities
SDG 13	Environmental sensing and climate action
SDG 15	Biodiversity monitoring

Course Title: Blockchain Technologies

Code	Course Title	Credit	L-T-P
CS40006	Blockchain Technologies	4	3-1-0

Course Objectives:

1. To provide students with a comprehensive understanding of blockchain technology, its underlying principles, and its application
2. Enabling them to design and implement blockchain solutions that address complex problems and contribute to technological innovation.

Course Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of blockchain technology, distributed ledger systems, cryptographic principles, consensus mechanisms, and blockchain architecture.

- **CO2 (Understanding):** Explain and interpret the principles of blockchain networks, consensus algorithms, smart contracts, decentralized applications, and blockchain security.
- **CO3 (Application):** Apply blockchain platforms, smart contract development tools, and decentralized application frameworks to design and implement blockchain-based solutions for real-world applications.
- **CO4 (Analysis):** Analyze and compare different blockchain architectures, consensus protocols, smart contract platforms, and security mechanisms to determine suitable solutions for various application domains.
- **CO5 (Synthesis/Evaluation):** Design, implement, and evaluate secure, scalable, and efficient blockchain-based systems by integrating smart contracts, decentralized applications, and emerging blockchain technologies to address industrial and societal challenges.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO2	-	3	-	-	3	-	-	-	-	-	-	-	-	-	-	2
CO3	-	3	-	3	2	-	-	-	-	-	-	-	3	-	2	-
CO4	-	-	3	-	-	-	-	2	-	-	-	-	-	3	-	3
CO5	-	-	3	-	-	-	-	-	-	-	-	-	2	2	-	3

Course Duration: 45 hours

Tutorial: 30 hours

Course Syllabus:

Unit 1: Introduction to Blockchain [9 Classroom Contact Hours]

Fundamentals of blockchain technology, History and evolution of blockchain, Cryptography and security principles

Unit 2: Blockchain Architecture [9 Classroom Contact Hours]

Distributed ledger technology, Consensus algorithms, Smart contracts and decentralized applications

Unit 3: Blockchain Development [9 Classroom Contact Hours]

Blockchain platforms: Ethereum, Hyperledger, etc., Development tools and environments, Building and deploying smart contracts

Unit 4: Blockchain for Business [9 Classroom Contact Hours]

Use cases in finance, supply chain, and other industries, Tokenization and digital assets, Regulatory environment and compliance

Unit 5: Advanced Topics in Blockchain [9 Classroom Contact Hours]

Scalability solutions and layer-two protocols, Privacy-preserving technologies, Future trends and challenges in blockchain

- **Textbook**:
  1. "Mastering Blockchain" by Imran Bashir

- **Reference Books**:
  1. "Blockchain: Blueprint for a New Economy" by Melanie Swan
  2. "Blockchain Revolution" by Don Tapscott and Alex Tapscott

SWAYAM Courses

Blockchain and its Applications - https://onlinecourses.nptel.ac.in/noc24_cs15/preview

SDG Mapping for this Course

SDG	Rationale
SDG 8	Financial inclusion, digital economy
SDG 9	Innovation in secure digital infrastructure
SDG 10	Reducing inequalities through decentralized systems
SDG 16	Transparent governance and anti-corruption

Course Title: Cloud Computing

Code	Course Title	Credit	L-T-P
CS40008	Cloud Computing	4	3-0-1

Course Objectives:

1. To provide students with a thorough understanding of cloud computing concepts, architectures, and services.
2. Enabling them to design, implement, and manage cloud-based solutions that address complex problems and demonstrate critical thinking and analytical reasoning.

Course Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of cloud computing, cloud architecture, virtualization, service models (IaaS, PaaS, SaaS), deployment models, and cloud infrastructure.
- **CO2 (Understanding):** Explain and interpret the principles of cloud resource management, virtualization, containerization, cloud storage, cloud networking, scalability, elasticity, and security mechanisms.
- **CO3 (Application):** Apply cloud computing platforms, virtualization technologies, container orchestration tools, and cloud services to design, develop, deploy, and manage cloud-based applications and solutions.
- **CO4 (Analysis):** Analyze and compare cloud architectures, service models, deployment strategies, resource allocation techniques, security frameworks, and performance optimization methods to develop efficient and scalable cloud solutions.
- **CO5 (Synthesis/Evaluation):** Design, implement, and evaluate secure, scalable, and cost-effective cloud computing solutions by integrating cloud platforms, virtualization, distributed computing, security practices, and cloud management tools for real-world applications.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	-	-	3	-	-	-	-	-	-	-	-	2	-	-	-
CO2	-	3	-	2	-	-	-	-	-	-	-	-	-	2	1	-

CO3	-	-	-	-	-	3	-	3	-	-	-	-	-	3	-	2
CO4	-	-	-	-	-	-	3	-	-	3	-	-	2	-	3	-
CO5	-	-	3	-	-	-	-	-	-	-	-	3	2	-	1	3

Course Duration: 45 hours

Course Syllabus:

Unit 1: Introduction to Cloud Computing [9 Classroom Contact Hours]

Fundamentals of cloud computing, Cloud service models (IaaS, PaaS, SaaS), Deployment models (public, private, hybrid, community)

Unit 2: Cloud Infrastructure and Virtualization [9 Classroom Contact Hours]

Data center technologies, Virtualization concepts and techniques, Cloud storage and computing resources

Unit 3: Cloud Services and Platforms [9 Classroom Contact Hours]

Web services and APIs, Cloud platforms (AWS, Azure, Google Cloud), Developing and deploying cloud applications

Unit 4: Cloud Security and Compliance [9 Classroom Contact Hours]

Security challenges in the cloud, Identity and access management, Legal, compliance, and privacy issues

Unit 5: Emerging Trends and Future of Cloud Computing [9 Classroom Contact Hours]

Serverless computing and microservices architecture, Cloud analytics and machine learning services, Future trends in cloud computing

Total Practical / Lab Experiments: [30 Lab Contact Hours]

1. Set up a virtual private cloud environment.
2. Implement a virtual machine and manage its lifecycle.
3. Deploy a web application on a PaaS platform.
4. Configure cloud storage and database services.
5. Develop a cloud security plan for an organization.
6. Create a compliance checklist for cloud deployment.
7. Analyze performance metrics of cloud services.
8. Implement a server less function and trigger it via an event.

9. Integrate machine learning APIs into an application.
10. Research and present on a current trend in cloud computing.

- **Textbook**:
  1. "Coud Computing: Concepts, Technology & Architecture" by Thomas Erl, Ricardo Puttini, and Zaigham Mahmood

- **Reference Books**:
  1. "Cloud Computing: Principles and Paradigms" edited by Rajkumar Buyya, James Broberg, and Andrzej M. Goscinski
  2. "Cloud Computing: From Beginning to End" by Ray J. Rafaels

SWAYAM Course

Cloud Computing - https://onlinecourses.nptel.ac.in/noc24_cs118/preview

SDG Mapping for this Course

SDG	Title	Contribution
SDG 4	Quality Education	Low-cost infra for learning/research
SDG 8	Decent Work and Economic Growth	Cloud-ready job skills
SDG 9	Industry, Innovation and Infra	Scalable digital backbone
SDG 12	Responsible Consumption/Prod.	Efficient resource pooling
SDG 13	Climate Action	Cloud for environmental analytics, but also energy focus

Course Title: Quantum Computing and Quantum Algorithms

Code	Course Title	Credit	L-T-P
CS40010	Quantum Computing and Quantum Algorithms	4	3-0-1

Course Objectives:

1. This course introduces students to the principles of quantum computing and quantum algorithms.
2. It develops an understanding of quantum mechanics, qubits, quantum gates, and quantum circuits while enabling learners to design and analyze quantum algorithms, implement quantum programs using modern frameworks, and explore applications in cryptography, optimization, artificial intelligence, and scientific computing.

Course Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of quantum computing, quantum mechanics, qubits, quantum states, quantum gates, quantum circuits, and quantum information.
- **CO2 (Understanding):** Explain and interpret the principles of quantum superposition, entanglement, quantum measurement, quantum circuit models, quantum algorithms, and quantum error correction.
- **CO3 (Application):** Apply quantum computing principles and quantum programming frameworks to design, implement, and simulate quantum circuits and algorithms for computational problem-solving.
- **CO4 (Analysis):** Analyze the performance and computational complexity of quantum algorithms, compare them with classical algorithms, and evaluate their applications in optimization, cryptography, machine learning, and scientific computing.
- **CO5 (Synthesis/Evaluation):** Design, develop, and optimize quantum algorithms and applications using appropriate quantum computing tools and programming frameworks while addressing practical challenges and emerging trends in quantum technologies.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	2	-	-	-	-	-	-	-	-	-	2	3	1	2	-
CO2	2	3	2	2	2	-	-	-	-	-	-	2	3	2	-	-

CO3	2	3	3	2	-	1	-	2	2	1	-	-	-	2	2	2
CO4	2	-	2	2	3	1	3	2	2	1	-	-	2	-	2	2
CO5	-	-	3	3	3	2	-	3	2	-	2	-	-	1	-	3

Course Duration: 45 hours

Course Syllabus

Unit 1: Fundamentals of Quantum Computing [8 Classroom Contact Hours]

Introduction to quantum computing, limitations of classical computing, fundamentals of quantum mechanics for computing, quantum states, qubits, Bloch sphere representation, superposition, entanglement, quantum measurement, Dirac notation, tensor products, quantum information, and overview of quantum computing architectures.

Unit 2: Quantum Gates and Quantum Circuits [10 Classroom Contact Hours]

Quantum logic gates, single-qubit gates (Pauli-X, Y, Z, Hadamard, Phase, T), multi-qubit gates (CNOT, SWAP, Toffoli, Fredkin), quantum circuit model, quantum teleportation, quantum dense coding, Bell states, quantum circuit optimization, reversible computation, and introduction to quantum programming frameworks.

Unit 3: Quantum Algorithms [10 Classroom Contact Hours]

Quantum parallelism, Quantum Fourier Transform (QFT), Deutsch and Deutsch–Jozsa algorithms, Bernstein–Vazirani algorithm, Simon's algorithm, Grover's search algorithm, Shor's factorization algorithm, quantum phase estimation, algorithm complexity, and comparison of classical and quantum algorithms.

Unit 4: Quantum Error Correction and Quantum Machine Learning [9 Classroom Contact Hours]

Quantum noise and decoherence, quantum error models, quantum error correction codes, fault-tolerant quantum computing, variational quantum circuits, quantum optimization, introduction to quantum machine learning, quantum neural networks, quantum support vector machines, and hybrid quantum-classical computing.

Unit 5: Quantum Computing Applications and Emerging Trends [8 Classroom Contact Hours]

Applications of quantum computing in cryptography, cybersecurity, optimization, artificial intelligence, machine learning, healthcare, finance, material science, drug discovery, cloud-

based quantum computing, quantum supremacy, quantum internet, ethical considerations, challenges, and future directions in quantum technologies.

Total Practical / Lab Experiments: [30 Lab Contact Hours]

1. Installation and setup of Quantum Platform.
2. Creation and visualization of quantum circuits.
3. Implementation of single- and multi-qubit quantum gates.
4. Simulation of Bell states and quantum entanglement.
5. Implementation of Deutsch–Jozsa algorithm.
6. Implementation of Grover's search algorithm.
7. Simulation of Quantum Fourier Transform (QFT).
8. Introduction to Shor's algorithm.
9. Quantum circuit optimization and performance analysis.
10. Mini project for a real-world quantum computing application.

- **Textbook:**

1. Michael A. Nielsen and Isaac L. Chuang, Quantum Computation and Quantum Information, 10th Anniversary Edition, Cambridge University Press.
2. N. David Mermin, Quantum Computer Science: An Introduction, Cambridge University Press.
3. Eleanor G. Rieffel and Wolfgang H. Polak, Quantum Computing: A Gentle Introduction, MIT Press.
4. Jack D. Hidary, Quantum Computing: An Applied Approach, 2nd Edition, Springer.

- **Reference Books:**

1. Phillip Kaye, Raymond Laflamme, and Michele Mosca, An Introduction to Quantum Computing, Oxford University Press.
2. Chris Bernhardt, Quantum Computing for Everyone, MIT Press.
3. Maria Schuld and Francesco Petruccione, Supervised Learning with Quantum Computers, Springer.
4. Colin P. Williams, Explorations in Quantum Computing, 2nd Edition, Springer.

5. Eric R. Johnston, Nic Harrigan, and Mercedes Gimeno-Segovia, Programming Quantum Computers, O'Reilly Media.

SDG Mapping for this Course

SDG	Rationale
SDG 4	Access to modern ICT skills
SDG 8	Employability in cloud-driven industries
SDG 9	Infrastructure modernization
SDG 13	Energy-efficient cloud practices

Course Title: Indigenous People and the Science of Gemmology

Code	Course Title	Credit	L-T-P
IK-5051	Indigenous People and the Science of Gemmology	4	3-1-0

Course Objectives:

The main objective of this course is to look at the course in a more general way, then Gemology mainly involves topics related to the identification of gems, physical and chemical properties of gems, differentiating gems on the various basis, grading and assorting gems, processing them, and designing them for accessories etc.

Course Outcomes

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of gemology, mineralogy, gemstone formation (genesis), classification, and occurrence of gemstones.
- **CO2 (Understanding):** Explain and interpret the physical, optical, and chemical properties of gemstones and the techniques used for their identification and characterization.

- **CO3 (Application):** Apply standard gemological methods and instruments to identify, classify, and characterize gemstones based on their physical and optical properties.
- **CO4 (Analysis):** Analyze and evaluate the quality, grading, cutting, engraving, and authenticity of gemstones using appropriate gemological techniques and standards.
- **CO5 (Synthesis/Evaluation):** Evaluate the origin of gemstone colours, treatment methods, and the scientific basis of their perceived healing properties, and assess their significance in gemological and commercial applications.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
CO2	-	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO3	-	3	-	-	-	-	-	-	-	-	-	-	-	-	2	-
CO4	-	-	3	-	-	-	-	-	-	-	-	-	2	-	-	-
CO5	-	-	3	-	-	2	-	-	-	-	-	-	-	-	-	2

Course Duration: 45 hours

Tutorial: 30 hours

Course Syllabus:

Unit I: Introduction to the world of Gemstones [12 Classroom Contact Hours]

Ancient history of Gem stones, Mythology related to Gem stones, Use of Gems among indigenous people, Crystallography, Study on crystal growth, formation of atomic lattice, origin and structure of gem stones, twinned crystal, Rough gemstone identification, knowledge of identification process.

UNIT 2: Properties of Gemstones [10 Classroom Contact Hours]

Physical and optical properties of gemstones, Grading parameters of gemstones, Various shapes and cutting of gemstones, Engraving on stones, drilled stones, Interlink of beauty,

rarity, durability and its effect on valuation, Internal and external factors that affects valuation.

UNIT 3: Colour and Healing Power [11 Classroom Contact Hours]

The healing power of Gem stones, Tribal concept on Gemstones, Scientific approach of gemstones, Top gemstones with their colours and healing qualities, Science behind different colours of gemstones and their healing effects, precious gemstones found in tribal areas. , Tribal ornaments having gemstones, semiprecious stones and their practical identification, organic gemstones, Ornament making techniques in both traditional and modern, Ornament design, stones used in fine and fashion jewelers, rare stones collection.

UNIT 4: Terminology and nomenclature [12 Classroom Contact Hours]

Terminology and nomenclature of gemstones as per Indian and International markets, weights used in the gem trade, Market system of gems buying and selling, Gems and human race, Career and jobs, Scope in Gemology, Gemology as a tool for tribal development.

- **Text Books:**

1. Colour encyclopedia of Gemstones by Joel. E. Arem
2. The Gemsstones Handbook by Arthur Thomas
3. Precious Stones, Vol-I & II: Max Bauer
4. Gemstones of the World: Walter Schumann
5. Gemology: Cornelius S. Hurlbut & Robert C Kammerling
6. Popular Gemology: Richard M Pearl
7. Dictionary of Gems and Gemology: Robert M Shiplley
8. Gemmolog: Peter G Read
9. Gem: Smiths Onian
10. Stoned:Jewellery,obsession: Aja Raden
11. Rocks,Minerals and Gems: John Farndon

SDG Mapping for this Course

SDG	Rationale
SDG 4	Education rooted in Indigenous knowledge
SDG 5	Gender roles in traditional gem practices
SDG 10	Empowering Indigenous communities

SDG 12	Sustainable resource use
SDG 15	Protecting natural mineral ecosystems
SDG 17	Partnerships with Indigenous communities

SEMESTER – III

Paper Code	Paper Name	Credits			Credits
		L	T	P	
RM50001	Research Methodology	3	1	0	4
CA50005 (For other Discipline)	Computer Application and Data Analysis	3	0	1	4
CA50007	Data Analysis and Visualization	3	0	1	4
RE50003	Research and Publication Ethics	2	0	0	2
Electives (Choose TWO)					
CS50031	Recommender Systems	3	0	1	4
CS50033	Machine Learning for Predictive Analytics	3	0	1	4
CS50035	Advanced Big Data Systems	3	1	0	4
CS50037	Soft Computing	3	0	1	4
IK50051	Indigenous Knowledge and Intellectual Property Rights	3	1	0	4
Total Credits: 18 + 4 = 22					

Course Title: Research Methodology

Code	Course Title	Credit	L-T-P
RM50001	Research Methodology	4	3-1-0

Course Objectives:

1. Provide exposure to various research techniques and methods (both quantitative and qualitative).
2. Build upon the basic assumptions in adopting different methodologies for different kinds of research themes.
3. Adopt appropriate methodologies for building upon hypotheses and analyzing research gaps.
4. Teach certain quantitative methods, statistical techniques and qualitative methods to collect and analyze the data would help them organize and analyze the information gathered by them.

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

- **CO1 (Knowledge/Remember):** Know the formulation of research problems and plan for their structural study.
- **CO2 (Understanding):** Understand the scope of collection of relevant data and their interpretations
- **CO3 (Application):** Apply the use of various statistical analysis for decision making.
- **CO4 (Analysis):** Apply different quantitative methods, statistical techniques and qualitative methods to collect and analyze the data.
- **CO5 (Synthesis/Evaluation):** Create the methodologies to build hypotheses and test them with appropriate methods.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	-	-	-	-	-	-	-	-	-	-	-	2	3	2	-
CO2	-	3	-	-	-	-	-	-	-	-	-	-	3	3	-	-
CO3	-	3	-	-	-	-	-	-	-	-	-	-	2	3	2	2
CO4	-	-	3	-	-	-	2	-	-	-	-	-	2	3	-	-
CO5	-	-	3	-	-	3	-	-	-	-	-	-	-	2	-	2

Course Duration: 45 hours

Tutorial: 30 hours

Course Syllabus

UNIT- I: Introduction To Research [12 Classroom Contact Hours]
Meaning of Research, Philosophy of Research, Motivation of Research, Importance and Scope of Research, Scientific Research Methods and its Application to Social Phenomenon, Introduction to various aspects of research methods, Types of Research.

UNIT- II: Research Design and Data Collection [12 Classroom Contact Hours]
Research Design: Meaning, Need and features of a good design, Types of Research Design , Literature Review and its Importance, Steps in the Process of Research**,** Write a Research Proposal**,** Write qualitative research for publication/communication ,Sources and Methods of Data Collection

UNIT- III: Research Problem and Types [12 Classroom Contact Hours]
Research Problem, Research objectives and its Formulation, Fundamental research questions, Research Variables, Measurement and Scaling: Measurement in Research, Measurement Scales, Source of Error in Measurement, Test of sound Measurement: Reliability and Validity, Qualitative Research, Ethnographic Study, Observation, Case Study Method, Interviewing, Schedule, Mail Survey Method, Action Research: PRA and RRA, Focused Group discussion (FGD)

UNIT-IV: Statistics [12 Classroom Contact Hours]
Descriptive Statistics: Frequency Distribution, Relative, Percentage and Cumulative Frequency Distribution, Graph and Diagrams: Two Variables Graphs, Bar Diagrams, Pie Diagram, Pictorial Diagrams, Measures of Central Tendency: Mean, Mode, Median, Measures of Variability: Range, Standard Deviation, Coefficient of Variation, Normal Distribution: Basic Concept only, Standard Scores. Correlation: Correlation Coefficient and its properties, Linear Regression: Regression coefficients, Line of Regressions, Relation between Regression Coefficients and Correlation Coefficient., Rank Correlation Coefficient, Biserial Correlation Coefficient, Coefficient of Determination

UNIT-V: Sampling [12 Classroom Contact Hours]
Sampling: Need for Sampling, Methods of Probability Sampling and Non probability Sampling, Sampling and Non sampling Error, Hypotheses: Concept of Population, Sample, Parameter and Statistic, Concept of Hypothesis, Types of Hypotheses, Formulation of

Hypothesis, Procedure of Testing of Hypothesis, Test of Significance, One- tailed and Two-tailed Test, Testing of Single Mean and Difference of Means, Parametric and Non parametric Test, Variable Analysis. Report Writing: Objective, Purpose of Report, Type of Reports, Report Writing Process, Guidelines for Effective Report Writing.

- **Textbook:**

1. Kothari, C.R. Research Methodology, Methods and Techniques –Wiley Eastern Limited – New Delhi
2. Ahuja, R (2010), Research Methods, Rawat Publication, Jaipur.
3. Sondhi N, Chawla D.(2nd Edition), Research Methodology, Vikas Publication.

- **Reference Book:**

1. "Creswell, John W (2009) Research design: qualitative, quantitative, and mixed methods approaches
2. Creswell, John W (2013) Qualitative inquiry and research design: choosing among five approaches
3. Garett, Henry, E Statistics in Psychology and Education – David Heley and Co.
4. Huberman, A. Michael (2002) Qualitative researcher's companion
5. Maxwell, Joseph (2005) Qualitative research design: an interactive approach
6. W.J. Goode and P. K. Hatt (1952) Methods in Social Research. Mc Graw Hill Co.

SWAYAM Course

Research Methodology - https://onlinecourses.swayam2.ac.in/nou24_cm17/preview

SDG Mapping for this Course

SDG	Rationale
SDG 4	Research-based higher education
SDG 9	Strengthening scientific research capacity
SDG 12	Responsible consumption in research
SDG 13	Climate-aware scientific inquiry

Course Title: Computer Application and Data Analysis

Code	Course Title	Credit	L-T-P
CA50005 (For Other	Computer Application and Data Analysis	4	3-0-1

discipline)			

Course Objectives:

1. Increase knowledge and requisite skills of participants on the use of SPSS
2. enable the students make the most of this powerful software package while allowing them to work independently with SPSS on their own data
3. Provide a solid foundation for advanced data analysis work.
4. Increase proficiency of scholars on the use of Basic computer Applications and SPSS.

Course Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of computer hardware, software, operating systems, and basic computer applications.
- **CO2 (Understanding):** Explain and interpret the features and applications of MS Office packages and various analytical and research software tools used for data organization, documentation, and presentation.
- **CO3 (Application):** Apply appropriate computer applications and statistical methods to formulate research hypotheses, organize data, and perform basic computational tasks.
- **CO4 (Analysis):** Analyze research data using statistical software such as SPSS and interpret the results to support evidence-based decision-making and problem-solving.
- **CO5 (Synthesis/Evaluation):** Design, implement, and evaluate data analysis workflows by integrating computer applications, MS Office tools, and SPSS to prepare professional reports and support research and organizational decision-making.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	-	-	-	-	-	-	-	-	-	-	-	2	3	-	-
CO2	-	3	-	3	2	-	-	-	-	-	-	-	-	3	-	-
CO3	-	-	3	-	-	-	-	-	-	-	-	-	2	-	2	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

CO5	-	-	3	-	2	-	-	-	-	-	-	-	-	2	-	2

Course Duration: 45 hours

Course Syllabus

Unit I: Computer Basic and Computer Fundamental [8 Classroom Contact Hours]

Hardware and Software, Functional units comprising a typical computer configuration: input/output, fixed and removable data storage, internal storage, control and arithmetic/logic unit, The concepts relating to execution speed, data access times, storage capacities and similar comparative aspects of hardware performance. Operating Systems: Windows, Linux etc. Application software, role and functions of commonly available applications, Computer Network Concept- Data communication and network terminology, IP address and its significance, Internet, Multimedia, WWW, FTP, E-mail, and Web pages. Concept of VPNs. Concept of Network security and management.

Unit II: Microsoft word [9 Classroom Contact Hours]

Creating and editing documents, formatting text and paragraph, formatting documents, creating and formatting tables, illustration documents with graphics. Creating a web page, mail merge and document merging, working with styles and templates, developing multi-page documents, integrating word with other applications, exploring advance graphics, building forms, working with charts and diagrams

Unit III: Microsoft Excel [9 Classroom Contact Hours]

Building and editing worksheets, formatting a worksheet, working with charts, Working with formulas and functions, managing workbooks and preparing them for the web, automating worksheet tasks with macros, using lists, analyzing list data, enhancing charts and worksheets Using analysis tools, Analyzing data with pivot tables, exchanging data with other programs.

Unit IV: Microsoft PowerPoint [9 Classroom Contact Hours]

Creating a presentation with Microsoft PowerPoint, modifying a presentation, inserting objects into presentation, finishing a presentation, Working with advanced tools and masters, enhancing charts, inserting illustration, objects and media clips, using advanced features.

Unit V: Statistical Analysis [10 Classroom Contact Hours]

The analysis will be done with the help of SPSS, and other statistical packages. M Descriptive Analysis: Mean, Median, Mode, Standard Deviation, Correlation. Regression Analysis, t- test, chi-square test, R-Square test, Factor Analysis, ANOVA, NVIVO, SPSS, JAMOVI, AMOS.

Total Practical / Lab Experiments: [30 Lab Contact Hours]

1. Create and format a table in Word with at least 5 rows × 5 columns; apply borders, shading, and sorting.
2. Perform a Mail Merge: prepare a personalized invitation letter using an Excel data source (name, address).
3. Build a student mark sheet with fields (Name, Roll, Subject Marks). Apply formulas for Total, Average, Percentage, and Grade.
4. Format the worksheet (merge cells, adjust column width, borders, number formatting). Apply conditional formatting (highlight marks <40 in red).
5. Create different charts (bar, pie, line) for student performance or sales data. Enhance charts with titles, legends, and labels.
6. Demonstrate formulas and functions:
   SUM, AVERAGE, MAX, MIN, COUNT, IF
7. Create a PowerPoint presentation (minimum 8 slides) on "Emerging Technologies in Computing." Include title slide, content slides, conclusion, and references.
8. Create a PowerPoint presentation (minimum 10 slides) on "Emerging Trends in Computer Science." Include:
   1. Slide designs, transitions, and animations
   2. Insert images, charts, and SmartArt
   3. Add audio or video clips
9. Input a dataset of student scores into SPSS. Perform Descriptive Statistics: Mean, Median, Mode, Standard Deviation, and Correlation. Generate graphs (histogram, scatter plot).
10. Using SPSS, perform Hypothesis Testing:
    - t-test for comparing two groups
    - Chi-square test for categorical data
    - ANOVA for comparing more than two groups
    - Report R-square and regression results with interpretations

- **Text Books:**

1. Hari Shankar Asthana, Braj Bhushan, Statistics for Social Sciences (With SPSS Applications, PHI Publication.
2. Jesus Salcedo, Keith Mccormick, SPSS Statistics for Dummies, 3rd Edition (Paperback), Wiley Publication.
3. Sabine Landau and Brian S. Everitt, A Handbook of Statistical Analysis Using SPSS

SDG Mapping for this Course

SDG	Rationale
SDG 4	Digital literacy
SDG 9	Data-driven innovation
SDG 10	Equity through unbiased data
SDG 17	Data for partnerships and policy

Course Title: Data Analysis and Visualization

Code	Course Title	Credit	L-T-P
CA50007	Data Analysis and Visualization	4	3-0-1

Course Objectives:

1. Increase knowledge and requisite skills of participants on the use of data analysis, visualization and on SPSS
2. Enable the students make the most of this powerful software package while allowing them to work independently with SPSS on their own data
3. Provide a solid foundation for advanced data analysis and visualization work.
4. Increase proficiency of scholars on the use of pandas, numpy, seaborn and SPSS.

Course Learning Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of data science, data visualization, data analytics, and the data science lifecycle.
- **CO2 (Understanding):** Explain and interpret the principles of data preprocessing, data wrangling, data aggregation, grouping operations, and the functionalities of Python libraries such as NumPy, Pandas, and Seaborn for data analysis and visualization.
- **CO3 (Application):** Apply Python programming, data science libraries, and statistical techniques to formulate hypotheses, preprocess datasets, perform exploratory data analysis, and generate meaningful visualizations.
- **CO4 (Analysis):** Analyze datasets using statistical and visualization tools, including SPSS and Python libraries, to identify patterns, interpret results, and support evidence-based decision-making.
- **CO5 (Synthesis/Evaluation):** Design, implement, and evaluate end-to-end data analysis and visualization workflows by integrating Python, SPSS, and visualization techniques to solve real-world data-driven problems and communicate actionable insights.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	-	-	-	-	-	-	-	-	-	-	-	3	3	-	3
CO2	-	3	-	2	2	-	-	-	-	-	-	-	-	3	2	-
CO3	-	-	3	-	-	-	-	-	-	-	-	-	2	-	-	3
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	3	-	3	-	-	-	-	-	-	-	2	-	-	2

Course Duration: 45 hours

Course Syllabus

Unit I: Introduction [8 Classroom Contact Hours]

Introduction to Data Science, Exploratory Data Analysis and Data Science Process, Motivation for using Python for Data Analysis, Introduction of Python shell iPython and

Jupyter Notebook, Essential Python Libraries: NumPy, pandas, matplotlib, SciPy, scikit-learn, statsmodels.

Unit-II: Getting Started with Pandas [9 Classroom Contact Hours]

Arrays and vectorized conputation, Introduction to pandas Data Structures, Essential Functionality, Summarizing and Computing Descriptive Statistics, Data Loading, Storage and File Formats. Reading and Writing Data in Text Format, Web Scraping, Binary Data Formats, Interacting with Databases Data Cleaning and Preparation. Handling Missing Data, Data Transformation.

Unit III: Data Wrangling [8 Classroom Contact Hours]

Hierarchical Indexing, Combining and Merging Data Sets Reshaping and Pivoting, Data Visualization matplotlib: Basics of matplotlib, plotting with pandas and seaborn, other python visualization tools.

Unit IV: Data Aggregation and Group operations [10 Classroom Contact Hours]

Group by Mechanics, Data aggregation, General split-apply-combine, Pivot tables and cross tabulation 67 Time Series Data Analysis: Date and Time Data Types and Tools, Time series Basics, date Ranges, Frequencies and Shifting, Time Zone Handling, Periods and Periods Arithmetic, Resampling and Frequency conversion.

Unit V: SPSS [10 Classroom Contact Hours]

SPSS, Descriptive Analysis: Mean, Median, Mode, Standard Deviation and Correlation. Regression Analysis, t-test, chi-square test, R- Square test, ANOVA using SPSS.

Total Practical / Lab Experiments: [30 Lab Contact Hours]

Practical Use data set of your choice from Open Data Portal (https://data.gov.in/) for the following exercises.

1. Practicals based on NumPy ndarray
2. Practicals based on Pandas Data Structures
3. Practicals based on Data Loading, Storage and File Formats
4. Practicals based on Interacting with Web APIs
5. Practicals based on Data Cleaning and Preparation

6. Practicals based on Data Wrangling
7. Practicals based on Data Visualization using matplotlib
8. Practicals based on Data Aggregation
9. Practicals based on Time Series Data Analysis

- **Text Books:**

1. Hari Shankar Asthana, Braj Bhushan, Statistics for Social Sciences (With SPSS Applications, PHI Publication.
2. Jesus Salcedo, Keith Mccormick, SPSS Statistics for Dummies, 3rd Edition (Paperback), Wiley Publication.
3. Sabine Landau and Brian S. Everitt, A Handbook of Statistical Analysis Using SPSS

- **References:**

1. McKinney, W.(2017). Python for Data Analysis: Data Wrangling with Pandas, NumPy and IPython. 2nd edition. O'Reilly Media.
2. O'Neil, C., & Schutt, R. (2013). Doing Data Science: Straight Talk from the Frontline O'Reilly Media.

SDG Mapping for this Course

SDG	Rationale
SDG 4	Data literacy
SDG 9	Innovation in analytics
SDG 10	Reducing inequality through transparent data
SDG 13	Climate data visualization

Course Title: Research and Publication Ethics

Code	Course Title	Credit	L-T-P
RE50003	Research and Publication Ethics	2	2-0-0

Course Objectives:

1. This course is focusing on basics of philosophy of science and ethics, research integrity, publication ethics, Hands on sessions are designed to identify research misconduct and predatory publications.

2. Indexing and citation databases, open access publications, research metrics (citation, hi-index, impact factor etc.) and plagiarism tools will be taught in this course.

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

- **CO1 (Knowledge/Remember):** Learn about basics of philosophy of science and ethics, research integrity
- **CO2 (Understanding):** Have awareness about the publication ethics and publication misconducts.
- **CO3 (Application):** Learn about the publication related databases and various research related tools.
- **CO4 (Analysis):** Develop knowledge about indexation and citation of publications.
- **CO5 (Synthesis/Evaluation):** Learn in and out of research publications.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	-	-	-	-	-	-	-	-	-	-	-	3	3	-	2
CO2	-	3	-	-	-	-	-	-	-	-	-	-	-	2	-	2
CO3	-	3	-	-	-	-	-	-	-	-	-	-	3	-	2	-
CO4	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	2
CO5	-	-	3	-	-	2	-	-	-	-	-	-	-	2	-	-

Course Duration: 30 hours

Course Syllabus

Unit 1: Philosophy and Ethics [3 Classroom Contact Hours]

Introduction of philosophy: Definition, nature and scope, concept, branches, Ethics: Definition, moral philosophy, nature of moral judgments and reactions.

Unit 2: Scientific Conduct [5 Classroom Contact Hours]

Ethics with respect to science and research, Intellectual honesty and research Integrity , Scientific Misconducts: Falsification, Fabrication and Plagiarism (FFP), Redundant

Publications: duplicate and overlapping publications, salami slicing, Selective Reporting and misrepresentation of data

Unit 3: Publication Ethics [7 Classroom Contact Hours]

Publication Ethics: Definition, introduction and importance, Best practices/standards setting initiatives and guidelines: COPE, WAME etc.Conflicts of interest, Publication misconduct: definition, concepts, problems that lead to unethical behaviour and *vice versa*, types, Violation of publication ethics, authorship and contributor-ship, Identification of publication, misconduct, complaints and appeals, Predatory publishers and journals

Unit 4: Open Access Publishing [4 Classroom Contact Hours]

Open access Publications and Initiatives, SHERPA/RoMEO online resource to check publisher copyright and self-archiving policies, Software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestion tools viz. JANE , Elsevier Journal finder, Springer journal suggester, etc.

Unit 5: Publication Misconduct [4 Classroom Contact Hours]

Ethical implications of emerging technologies in research, Environmental and sustainability considerations in research, Ethical issues in big data and AI research, Future trends and challenges in research ethics, Developing a personal ethical framework for research

Unit 6: Data Bases and Research Metrics [7 Classroom Contact Hours]

A. Databases

i.Indexing Databases

ii.Citation Databases: Web of Science, Scopus etc.

B. Research Metrics

i.Impact factor of journal as per Journal Citation Report, SNIP, SJR, IPP,Cite Score

ii.Metrics: h-index, g index, I 10 index, alt metrics

- **Textbook:**

1. S. B. Kishor, A.S. Kushwaha, Research and Publication Ethics, Das Ganu Prakashan, Nagpur,
2. Y. Sharma., A. Sharma, Textbook of Research and Publication Ethics, Kalyani Publishers.

- **Reference Books:**

1. The students' guide to Research Ethics by Paul Oliver Open University Press, 2003
2. Responsible conduct of Research by Adil E. Shamoo; David B. Resnik Oxford University Press, 2003
3. Anderson B.H., Dursaton, and Poole M.: Thesis and Assignment writing, Wiley Eastern 1997.

Swayam Link

https://onlinecourses.swayam2.ac.in/nou24_ge73/preview

SDG Mapping for this Course

SDG	Rationale
SDG 4	Quality research education
SDG 5	Gender-fair authorship
SDG 9	Ethical innovation
SDG 16	Justice, transparency, strong institutions

Course Title: Recommender Systems

Code	Course Title	Credit	L-T-P
CS50031	Recommender Systems	4	3-0-1

Course Objectives:

1. To provide students with an in-depth understanding of recommender systems.
2. Enabling them to design, implement, and evaluate recommendation algorithms for various applications.
3. Fostering critical thinking, analytical reasoning, and collaborative skills.

Course Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of recommender systems, recommendation techniques, user profiling, item profiling, and evaluation methods.
- **CO2 (Understanding):** Explain and interpret the principles of collaborative filtering, content-based filtering, hybrid recommendation approaches, knowledge-based recommendation, and recommendation evaluation metrics.
- **CO3 (Application):** Apply recommendation algorithms, machine learning techniques, and appropriate software tools to design and implement recommender systems for personalized recommendation applications.
- **CO4 (Analysis):** Analyze and compare different recommendation algorithms, similarity measures, evaluation metrics, and optimization techniques to identify suitable approaches for diverse recommendation scenarios.
- **CO5 (Synthesis/Evaluation):** Design, implement, and evaluate scalable, accurate, and intelligent recommender systems by integrating collaborative filtering, content-based methods, hybrid approaches, and emerging artificial intelligence techniques to address real-world personalization challenges.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	-	-	-	-	-	-	-	-	-	-	-	3	3	-	2
CO2	-	3	-	2	3	-	-	-	-	-	-	-	2	3	2	-
CO3	-	3	-	2	-	-	-	-	-	-	-	-	-	2	-	2
CO4	-	-	3	-	-	-	2	-	-	-	-	-	2	2	-	-
CO5	-	-	3	-	-	3	-	-	-	-	-	-	2	-	2	2

Course Duration: 45 Hours

Course Syllabus:

Unit 1: Introduction to Recommender Systems [8 Classroom Contact Hours]

Overview of recommender systems and their importance, Types of recommender systems: Collaborative filtering, content-based, hybrid, Data collection and preprocessing for recommendations, Evaluation metrics: Precision, recall, F1 score, RMSE, MAE, Case studies of recommender systems in various domains

Unit 2: Collaborative Filtering Techniques [9 Classroom Contact Hours]

User-based and item-based collaborative filtering, Similarity measures: Cosine, Pearson, Jaccard, Matrix factorization techniques: SVD, SVD++, Implicit feedback and its handling, Scalability and performance considerations

Unit 3: Content-Based Recommender Systems [9 Classroom Contact Hours]

Feature extraction and representation, TF-IDF, word embeddings, and other feature engineering techniques, Content-based filtering algorithms, Hybrid recommender systems: Combining collaborative and content-based methods, Practical implementation using Python libraries

Unit 4: Advanced Recommender System Techniques [10 Classroom Contact Hours]

Context-aware recommender systems, Sequence-aware and session-based recommendations, Deep learning for recommender systems: Autoencoders, neural collaborative filtering, Explainability and interpretability in recommender systems, Ethical considerations and bias in recommendations

Unit 5: Applications and Future Directions [9 Classroom Contact Hours]

Recommender systems in e-commerce, social media, and entertainment, Personalized recommendations and user profiling, Real-time and online recommendation systems, Emerging trends and research directions in recommender systems, Sustainability and environmental impact of recommender systems

Total Practical / Lab Experiments: [30 Lab Contact Hours]

1. Implement a user-based collaborative filtering algorithm.
2. Develop an item-based collaborative filtering system.
3. Calculate similarity measures for a given dataset.
4. Perform matrix factorization using SVD on a recommendation dataset.
5. Handle implicit feedback in a recommendation system.
6. Extract features from text data using TF-IDF.
7. Implement a content-based recommender system.
8. Combine collaborative and content-based methods to create a hybrid recommender.
9. Develop a context-aware recommendation system.

10. Implement a session-based recommendation algorithm.
11. Use autoencoders for collaborative filtering.
12. Develop a neural collaborative filtering model.
13. Evaluate the performance of different recommendation algorithms.
14. Implement a real-time recommendation system.
15. Analyze the ethical implications of recommender systems.
16. Collaborate on a group project to develop a comprehensive recommender system.
17. Write a report on the application of recommender systems in a specific domain.
18. Present a case study on the use of recommender systems in e-commerce.
19. Research and present on the future trends in recommender systems.
20. Participate in a debate on the environmental impact of recommender systems.

- **Textbook:**
  1. **"**Recommender Systems: An Introduction" by Dietmar Jannach, Markus Zanker, Alexander Felfernig, and Gerhard Friedrich

- **Reference Books:**
  1. **"**Recommender Systems Handbook" by Francesco Ricci, Lior Rokach, and Bracha Shapira
  2. "Practical Recommender Systems" by Kim Falk
  3. "Deep Learning for Recommender Systems" by Alexandros Karatzoglou, Balázs Hidasi, and Domonkos Tikk

SDG Mapping for this Course

SDG	Rationale
SDG 4	Personalized learning systems
SDG 9	Intelligent systems innovation
SDG 10	Reducing bias in recommendations
SDG 12	Sustainable consumption recommendations

Course Title: Machine Learning for Predictive Analytics

Code	Course Title	Credit	L-T-P
CS50033	Machine Learning for Predictive Analytics	4	3-0-1

Course Objective:

1. To provide students with advanced knowledge and skills in machine learning techniques for predictive analytics.
2. Eabling them to analyze data, build predictive models, and apply these models to solve complex problems, while fostering critical thinking, analytical reasoning, and collaborative skills.

Course Outcomes:

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of predictive analytics, machine learning, data preprocessing, feature engineering, and predictive modeling techniques.
- **CO2 (Understanding):** Explain and interpret the principles of supervised and unsupervised learning, model training, validation techniques, feature selection, and performance evaluation metrics used in predictive analytics.
- **CO3 (Application):** Apply machine learning algorithms, statistical methods, and appropriate software tools and frameworks to develop predictive models for classification, regression, forecasting, and decision-making applications.
- **CO4 (Analysis):** Analyze and compare different predictive models, feature selection methods, validation techniques, and evaluation metrics to identify the most suitable approaches for diverse predictive analytics problems.
- **CO5 (Synthesis/Evaluation):** Design, implement, and evaluate robust and scalable predictive analytics solutions by integrating machine learning algorithms, data preprocessing techniques, model optimization, and performance evaluation to solve real-world data-driven problems.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	-	-	-	-	-	-	-	-	-	-	-	3	3	2	-

CO2	-	3	-	2	3	-	-	-	-	-	-	-	3	3	-	3
CO3	-	3	-	2	-	-	-	3	-	-	-	-	-	-	3	-
CO4	-	-	3	-	-	-	2	-	-	-	-	-	2	3	-	-
CO5	-	-	3	-	-	3	-	-	-	-	-	-	3	2	-	2

Course Duration: 45 Hours

Course Syllabus:

Unit 1: Introduction to Predictive Analytics and Machine Learning [8 Classroom Contact Hours]

Overview of predictive analytics and its importance, Basic concepts of machine learning: Supervised, unsupervised, and reinforcement learning, Data pre-processing and feature engineering, Introduction to Python libraries for machine learning: scikit-learn, pandas, numpy, Case studies of predictive analytics applications

Unit 2: Regression and Classification Techniques [9 Classroom Contact Hours]

Linear regression and logistic regression, Decision trees and random forests, Support vector machines (SVM), k-Nearest Neighbors (k-NN), Model evaluation metrics: Accuracy, precision, recall, F1 score, ROC-AUC

Unit 3: Ensemble Methods and Model Optimization [10 Classroom Contact Hours]

Bagging and boosting techniques: AdaBoost, Gradient Boosting, XGBoost, Hyper parameter tuning and model selection, Cross-validation and grid search, Feature selection and dimensionality reduction, Practical implementation using Python

Unit 4: Advanced Machine Learning Techniques [9 Classroom Contact Hours]

Neural networks and deep learning basics, Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), Time series forecasting and analysis, Anomaly detection and outlier analysis, Practical implementation using TensorFlow and Keras

Unit 5: Applications and Future Directions [9 Classroom Contact Hours]

Predictive analytics in finance, healthcare, and marketing, Ethical considerations and bias in predictive models, Explainability and interpretability of machine learning models, Emerging trends and research directions in predictive analytics, Sustainability and environmental impact of machine learning

Total Practical / Lab Experiments: [30 Lab Contact Hours]

1. Preprocess a dataset and perform feature engineering.
2. Implement linear regression and evaluate its performance.
3. Develop a logistic regression model for binary classification.
4. Build a decision tree classifier and analyze its results.
5. Implement a random forest model and compare it with a decision tree.
6. Train a support vector machine (SVM) for a classification task.
7. Implement k-Nearest Neighbors (k-NN) for a given dataset.
8. Perform hyperparameter tuning using grid search.
9. Apply cross-validation techniques to evaluate model performance.
10. Implement AdaBoost and evaluate its effectiveness.
11. Develop a gradient boosting model using XGBoost.
12. Perform feature selection and dimensionality reduction.
13. Build a neural network using TensorFlow or Keras.
14. Implement a Convolutional Neural Network (CNN) for image classification.
15. Develop a Recurrent Neural Network (RNN) for time series forecasting.
16. Detect anomalies in a dataset using machine learning techniques.
17. Analyze the ethical implications of a predictive model.
18. Collaborate on a group project to develop a predictive analytics solution.
19. Write a report on the application of predictive analytics in a specific industry.
20. Present a case study on the use of machine learning for predictive analytics.

- **Textbook:**
  1. **"**Introduction to Machine Learning with Python: A Guide for Data Scientists" by Andreas C. Müller and Sarah Guido.
- **Reference Books:**
  1. "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" by Aurélien Géron.
  2. "Pattern Recognition and Machine Learning" by Christopher M. Bishop.
  3. "Machine Learning: A Probabilistic Perspective" by Kevin P. Murphy.

SDG Mapping for this Course

SDG	Rationale
SDG 3	Health predictions
SDG 8	Business forecasting

SDG 9	AI innovation
SDG 13	Climate forecasting

Course Title: Advanced Big Data Systems

Code	Course Title	Credit	L-T-P
CS50035	Advanced Big Data Systems	4	3-1-0

Course Objectives:

1. This course provides an in-depth understanding of advanced big data systems, distributed computing frameworks, scalable storage architectures, cloud-based data processing, and real-time analytics.
2. It equips students with the knowledge and practical skills to design, implement, optimize, and manage large-scale data systems for enterprise, scientific, and industrial applications.

Course Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of advanced big data systems, distributed computing, scalable storage architectures, Hadoop ecosystem, NoSQL databases, and cloud-based data processing frameworks.
- **CO2 (Understanding):** Explain and interpret the principles of distributed file systems, parallel data processing, resource management, stream processing, cloud computing, and data pipeline architectures for large-scale data systems.

- **CO3 (Application):** Apply advanced big data technologies, distributed computing frameworks, and cloud platforms to design, develop, and deploy scalable data storage, processing, and analytics solutions for real-world applications.
- **CO4 (Analysis):** Analyze the performance, scalability, reliability, and security of big data systems, evaluate distributed processing frameworks, and optimize data pipelines for efficient enterprise and scientific computing.
- **CO5 (Synthesis/Evaluation):** Design, implement, and evaluate advanced big data architectures by integrating distributed storage, cloud computing, real-time processing, and modern big data frameworks to solve complex data-intensive problems.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	2	-	-	-	-	-	1	-	-	-	-	3	3	-	-
CO2	2	3	2	2	3	-	-	-	-	-	-	2	2	3	2	-
CO3	2	3	-	2	-	-	-	2	-	1	-	-	-	2	3	-
CO4	2	-	3	3	3	1	2	-	2	1	-	-	2	2	-	2
CO5	-	-	2	-	-	2	2	-	2	-	2	3	-	3	-	2

Course Duration: 45 Hours

Tutorial: 30 hours

Course syllabus:

Unit 1: Foundations of Advanced Big Data Systems [8 Classroom Contact Hours]

Evolution of big data systems, characteristics of big data (5Vs and beyond), distributed computing concepts, distributed file systems, Hadoop architecture, Hadoop Distributed File System (HDFS), Yet Another Resource Negotiator (YARN), cluster architecture, resource management, fault tolerance, scalability, and big data system architecture.

Unit 2: Big Data Storage and Processing Frameworks [10 Classroom Contact Hours]

MapReduce programming model, Hadoop ecosystem, Apache Hive, Apache Pig, HBase, Sqoop, Flume, Oozie, ZooKeeper, NoSQL databases, MongoDB, Cassandra, data partitioning, replication, indexing, and distributed storage optimization.

Unit 3: In-Memory and Real-Time Data Processing [10 Classroom Contact Hours]
Apache Spark architecture, Spark Core, Spark SQL, Spark DataFrames, Spark Streaming, Resilient Distributed Datasets (RDDs), Apache Kafka, Apache Flink, real-time stream processing, event-driven architectures, workflow scheduling, and performance optimization.

Unit 4: Cloud-Based Big Data Systems [9 Classroom Contact Hours]
Cloud computing for big data, cloud storage services, distributed data processing on AWS, Microsoft Azure, and Google Cloud Platform, containerization using Docker, Kubernetes orchestration, data lakes, ETL pipelines, workflow automation, security, privacy, governance, and cloud-native big data architectures.

Unit 5: Enterprise Applications and Emerging Trends [8 Classroom Contact Hours]
Big data security and privacy, data governance, big data visualization tools, MLOps for big data systems, Internet of Things (IoT) data platforms, edge computing, digital twins, Industry 4.0 and Industry 5.0 applications, AI-driven big data systems, green computing, and future trends in distributed data systems.

- **Textbook:**
    1. Tom White, Hadoop: The Definitive Guide, 4th Edition, O'Reilly Media.
    2. Bill Chambers and Matei Zaharia, Spark: The Definitive Guide, O'Reilly Media.
    3. Nathan Marz and James Warren, Big Data: Principles and Best Practices of Scalable Realtime Data Systems, Manning Publications.
    4. Jules S. Damji, Brooke Wenig, Tathagata Das, and Denny Lee, Learning Spark: Lightning-Fast Data Analytics, 2nd Edition, O'Reilly Media.

- **Reference Books:**
    1. Viktor Mayer-Schönberger and Kenneth Cukier, Big Data: A Revolution That Will Transform How We Live, Work, and Think, Eamon Dolan/Houghton Mifflin Harcourt.

2. Dean Wampler and Jason Rutherglen, Programming Spark with Python, O'Reilly Media.
3. Alex Holmes, Hadoop in Practice, 2nd Edition, Manning Publications.
4. Mohammed Guller, Big Data Analytics with Spark, Apress.
5. Benjamin Bengfort and Jenny Kim, Data Analytics with Hadoop, O'Reilly Media.

SDG Mapping for this Course

SDG	Rationale
SDG 9	Data-driven innovation
SDG 11	Smart cities
SDG 13	Climate analytics
SDG 17	Data for global partnerships

Course Title: Soft Computing

Code	Course Title	Credit	L-T-P
CS50037	Soft Computing	4	3-0-1

Course Objectives:

1. To provide students with advanced knowledge and skills in soft computing techniques.
2. Enabling them to solve complex problems using fuzzy logic, neural networks, genetic algorithms, and other soft computing methods, while fostering critical thinking, analytical reasoning, and collaborative skills.

Course Outcomes:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of soft computing, fuzzy logic, artificial neural networks, evolutionary computing, genetic algorithms, and swarm intelligence.
- **CO2 (Understanding):** Explain and interpret the principles of fuzzy inference systems, neural network learning algorithms, evolutionary optimization techniques, and hybrid soft computing models.
- **CO3 (Application):** Apply soft computing techniques, algorithms, and appropriate software tools to design and implement intelligent solutions for classification, optimization, prediction, and decision-making problems.

- **CO4 (Analysis):** Analyze and compare different soft computing techniques, optimization algorithms, learning models, and performance evaluation methods to determine suitable approaches for solving complex computational problems.
- **CO5 (Synthesis/Evaluation):** Design, implement, and evaluate intelligent soft computing systems by integrating fuzzy logic, neural networks, evolutionary algorithms, and hybrid models to solve real-world engineering, business, and research problems.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-
CO2	-	3	-	2	3	-	-	-	-	-	-	-	-	2	-	2
CO3	-	3	-	-	-	-	-	3	-	-	-	-	3	2	-	-
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	3	-	-	2	-	-	-	-	-	-	2	-	-	2

Course Duration: 45 Hours

Course syllabus:

Unit 1: Introduction to Soft Computing [8 Classroom Contact Hours]

Overview of soft computing and its importance, Differences between hard computing and soft computing, Components of soft computing: Fuzzy logic, neural networks, genetic algorithms, Applications of soft computing in various domains, Case studies of soft computing applications

Unit 2: Fuzzy Logic [10 Classroom Contact Hours]

Introduction to fuzzy sets and fuzzy logic, Fuzzy set operations and properties, Fuzzy relations and fuzzy inference systems, Fuzzy rule-based systems and fuzzy control systems, Applications of fuzzy logic in decision making and control

Unit 3: Neural Networks [10 Classroom Contact Hours]

Introduction to artificial neural networks (ANN), Architecture of neural networks: Perceptron, multilayer perceptron, and backpropagation, Training and learning in neural networks, Deep learning and convolutional neural networks (CNN), Applications of neural networks in pattern recognition and classification

Unit 4: Genetic Algorithms [8 Classroom Contact Hours]

Introduction to genetic algorithms (GA), Genetic operators: Selection, crossover, and mutation, Fitness function and genetic algorithm optimization, Hybrid approaches: Combining GA with other soft computing techniques, Applications of genetic algorithms in optimization and search problems

Unit 5: Advanced Topics and Applications [9 Classroom Contact Hours]

Hybrid soft computing techniques: Neuro-fuzzy systems, genetic fuzzy systems, Swarm intelligence and particle swarm optimization (PSO), Evolutionary algorithms and their applications, Ethical considerations and sustainability in soft computing, Future trends and research directions in soft computing

Total Practical / Lab Experiments: [30 Lab Contact Hours]

1. Implement basic fuzzy set operations using Python.
2. Develop a fuzzy inference system for a decision-making problem.
3. Design a fuzzy control system for a real-world application.
4. Implement a perceptron model for a classification task.
5. Train a multilayer perceptron using backpropagation.
6. Develop a convolutional neural network (CNN) for image recognition.
7. Implement a genetic algorithm for an optimization problem.
8. Perform selection, crossover, and mutation operations in a GA.
9. Develop a hybrid neuro-fuzzy system for a complex problem.
10. Implement particle swarm optimization (PSO) for a search problem.
11. Evaluate the performance of different soft computing techniques.
12. Analyze the ethical implications of using soft computing in decision making.
13. Collaborate on a group project to develop a soft computing application.
14. Write a report on the application of soft computing in a specific domain.

15. Present a case study on the use of fuzzy logic in control systems.
16. Develop a neural network model for a pattern recognition task.
17. Implement a genetic algorithm for a real-world optimization problem.
18. Analyze the sustainability aspects of soft computing techniques.
19. Research and present on the future trends in soft computing.
20. Participate in a debate on the ethical considerations of soft computing.

- **Textbook:**
  1. "Soft Computing and Intelligent Systems Design" by Fakhreddine O. Karray and Clarence De Silva
- **Reference Books:**
  1. "Neural Networks and Learning Machines" by Simon Haykin
  2. "Fuzzy Logic with Engineering Applications" by Timothy J. Ross
  3. "Genetic Algorithms in Search, Optimization, and Machine Learning" by David E. Goldberg.

SDG Mapping for this Course

SDG	Rationale
SDG 4	Advanced computational education
SDG 9	Intelligent optimization systems
SDG 13	Energy and climate optimization
SDG 15	Ecological modelling

Course Title: Indigenous Knowledge and Intellectual Property Rights

Subject Code	Name of the Subject	L	T	P	Credit
IK-5052	Indigenous Knowledge and Intellectual Property Rights	**3**	**1**	**0**	**4**

Course Objectives:

1. Intellectual Property Rights: Concept and meaning.
2. Indian Patent Law (a) The Patents Acts

3. Copyright, Neighbouring Rights and Industrial Designs. Introduction to Copyright
4. Geographical Indications: Concept of Appellations of Origin.

Course Outcomes

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of Intellectual Property Rights (IPR), its types, significance, and the legal framework governing intellectual property.
- **CO2 (Understanding):** Explain and interpret the provisions of the Indian Patent Law, Patent Act, patent filing procedures, and the rights and obligations of patent holders.
- **CO3 (Application):** Apply the principles of copyright, neighbouring rights, industrial designs, trademarks, and related intellectual property laws to protect creative and innovative works.
- **CO4 (Analysis):** Analyze and compare geographical indications, industrial designs, patents, and other forms of intellectual property to determine their legal protection and commercial significance.
- **CO5 (Synthesis/Evaluation):** Evaluate intellectual property case studies, patent applications, industrial designs, and legal issues to recommend appropriate strategies for protecting innovation and ensuring compliance with intellectual property laws.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-
CO2	-	3	-	-	2	-	-	-	-	-	-	-	-	-	-	-
CO3	-	2	-	-	-	-	-	2	-	-	-	-	-	2	-	2
CO4	2	-	-	2	-	-	-	-	-	-	-	-	3	-	2	-
CO5	-	-	3	-	-	2	-	-	-	-	-	-	2	-	-	2

Course Duration: 45 hours

Tutorial: 30 hours

Course Syllabus

UNIT I: Introduction to Intellectual Property Rights [12 Classroom Contact Hours]

Concept and meaning, Theories of Property - An Overview, Intellectual Property as an Instrument of Development, Introduction to Patent Law (a) Paris Convention (b) Patent Cooperation Treaty (c) WTO- TRIPS (d) Harmonisation of CBD and TRIPs

UNIT 2: Indian Patent Law [12 Classroom Contact Hours]

Indian Patent Law (a) The Patents Act, 1970 (b) Amendments to the Patents Act (c) Patentable Subject Matter, Patentability Criteria (d) Procedure for Filing Patent Applications, Patent Granting Procedure (e) Revocation, Patent Infringement and Remedies (f) Relevant Provisions of the Biological Diversity Act, 2002 (g) Access and Benefit Sharing Issues

UNIT 3: Copyright, Neighbouring Rights and Industrial Designs [12 Classroom Contact Hours]

Copyright, Neighbouring Rights and Industrial Designs. Introduction to Copyright, Indian Copyright Law: (a) The Copyright Act, 1957 with its amendments (b) Copyright works (c) Ownership, transfer and duration of Copyright (d) Renewal and Termination of Copyright (e) Neighbouring Rights (f) Infringement of copyrights and remedies

UNIT 4: Geographical Indications [9 Classroom Contact Hours]

Geographical Indications, Layout designs of Integrated Circuits and Protection of Plant Varieties and Farmers' Rights, Geographical Indications: Concept of Appellations of Origin, Indication of Source and Geographical Indication, The Geographical Indications of Goods, Infringement, Penalties and Remedies, Layout-Designs of Integrated Circuits: Conditions and Procedure for Registration, Duration and Effect of Registration, Assignment and Transmission, The Protection of Plant Varieties and Farmers' Rights: The Protection of Plant Varieties and Farmer's Rights Act, 2001., Protection of Plant Varieties and Farmers' Rights, Registration of Plant Varieties and Essentially derived variety, Duration, Effect of Registration and Benefit Sharing, Farmers' Rights, Plant Varieties Protection Appellate Tribunal, Infringement, Offences, Penalties and Procedure, Industrial Designs (a) Need for Protection of Industrial Designs (b) Subject Matter of Protection and Requirements (c) The Designs Act, 2000 (d) Procedure for obtaining Design Protection (e) Revocation, Infringement and Remedies

- **Text Books:**

1. Arai, Hisamitsu. "Intellectual Property Policies for the Twenty-First Century: The Japanese Experience in Wealth Creation", WIPO Publication Number 834 (E). 2000. wipo.int
2. Bettig, R. V. (1996). Critical Perspectives on the History and Philosophy of Copyright. In R. V. Bettig, Copyrighting Culture: The Political Economy of Intellectual Property. (pp. 9–32). Boulder, CO: Westview Press.
3. Boldrin, Michele and David K. Levine. "Against Intellectual Monopoly", 2008. dkleving.com
4. Branstetter, Lee, Raymond Fishman and C. Fritz Foley. "Do Stronger Intellectual Property Rights Increase International Technology Transfer? Empirical Evidence from US Firm-Level Data". NBER Working Paper 11516. July 2005. weblog.ipcentral.info
5. Burk, Dan L. and Mark A. Lemley (2009). The Patent Crisis and How the Courts Can Solve It. University of Chicago Press. ISBN 978-0-226-08061-1.
6. Connell, Shaun. "Intellectual Ownership". October 2007. rebithofffreedom.org
7. De George, Richard T. "14. Intellectual Property Rights." In The Oxford Handbook of Business Ethics, by George G. Brenkert and Tom L. Beauchamp, 1:408-439. 1st ed. Oxford, England: Oxford University Press, n.d.
8. Farah, Paolo and Cima, Elena. "China's Participation in the World Trade Organization: Trade in Goods, Services, Intellectual Property Rights and Transparency Issues" in Aurelio Lopez-Tarruella Martinez (ed.), El comercio con China. Oportunidades empresariales, incertidumbres jurídicas, Tirant lo Blanch, Valencia (Spain) 2010, pp. 85–121. ISBN 978-84-8456-981-7. Available at SSRN.com
9. Farah, Paolo Davide, Tremolada Riccardo, Desirability of Commodification of Intangible Cultural Heritage: The Unsatisfying Role of IPRs, in TRANSNATIONAL DISPUTE MANAGEMENT, Special Issues "The New Frontiers of Cultural Law: Intangible Heritage Disputes", Volume 11, Issue 2, March 2014, ISSN 1875-4120Available at SSRN.comFarah, Paolo Davide, Tremolada Riccardo, Intellectual
10. Property Rights, Human Rights and Intangible Cultural Heritage, Journal of Intellectual Property Law, Issue 2, Part I, June 2014, ISSN 0035-614X, Giuffre, pp. 21–47. Available at SSRN.com

SDG Mapping for this Course

SDG	Rationale
SDG 4	Education rooted in Indigenous knowledge
SDG 5	Gender roles in knowledge transmission
SDG 10	Empowering Indigenous communities
SDG 12	Sustainable resource use
SDG 15	Biodiversity and ecosystem protection
SDG 16	Justice and rights protection
SDG 17	Partnerships with Indigenous communities

SEMESTER – IV

Paper Code	Paper Name	Credits			Credits
		L	T	P	
RT50082	Research Thesis	0	0	20	20
Total Credits: 20					

Course Objectives:

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

- **CO1 (Knowledge/Remember):** Recall and describe the fundamental concepts of computational research, research methodology, data collection methods, data interpretation, and data presentation techniques.
- **CO2 (Understanding):** Explain and interpret the principles of problem identification, research design, fieldwork, data collection, data analysis, and report writing for addressing societal and scientific issues.
- **CO3 (Application):** Apply appropriate research methods, data analysis techniques, and computational tools to investigate technical and societal problems and prepare structured research reports.
- **CO4 (Analysis):** Analyze and evaluate research data, documentation methods, and presentation techniques to ensure accurate interpretation and effective communication of research findings.

- **CO5 (Synthesis/Evaluation):** Design, prepare, and evaluate academic manuscripts, research reports, and scholarly publications by integrating ethical research practices, scientific writing standards, and publication guidelines.

CO-PO-PSO Mapping

*(Rate correlations: **1** - Weakly Mapped, **2** - Moderately Mapped, **3** - Strongly Mapped, **"_"** - No Correlation).*

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
CO1	3	-	3	-	-	-	-	-	-	-	-	-	3	3	2	2
CO2	-	-	3	3	2	-	-	-	-	-	-	-	2	3	2	2
CO3	-	-	-	-	3	3	-	-	-	-	-	-	2	3	2	2
CO4	-	-	-	-	-	-	2	-	3	-	-	-	2	3	2	2
CO5	-	-	-	-	-	-	-	-	-	3	-	3	2	3	2	2

Mode of Evaluation

Sl. No	Mode of Evaluation	Credits
1	Selection of Research Topic and Synopsis Presentation	4
2	Literature Review and Preparation of Research Tools (Questionnaires and schedule)	4
3	Data Collection (Primary/ Secondary)	4
4	Data Analysis, Model building and Report Writing	4
5	Seminar Presentation and Viva voce test on dissertation	4

- **References / Suggested Readings**

1. Kothari, C. R., & Garg, G. (2019). Research Methodology: Methods and Techniques (4th ed.). New Delhi, India: New Age International Publishers.
2. Creswell, J. W., & Creswell, J. D. (2018). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (5th ed.) Thousand Oaks, CA: SAGE Publications.
3. Mbanaso, U. M., Kumar, A., Mishra, D., & Sharma, R. (2023). Research Techniques for Computer Science, Information Systems and Cybersecurity. Cham, Switzerland: Springer Nature.
4. Booth, W. C., Colomb, G. G., Williams, J. M., Bizup, J., & Fitzgerald, W. T. (2016). The Craft of Research (4th ed.). Chicago, IL: University of Chicago Press.

5. Zobel, J. (2014). Writing for Computer Science (3rd ed.). London, UK: Springer.

SDG Mapping for this Course

SDG	Relevance to Research Thesis / Project / Patent
SDG 4	Strengthens advanced research capability, innovation, and higher-order learning.
SDG 5	Encourages gender-inclusive research and equitable representation in data and analysis.
SDG 8	Builds employability, innovation, entrepreneurship, and patent-oriented skills.
SDG 9	Directly contributes through prototypes, models, systems, and patentable technologies.
SDG 10	Supports inclusive research, Indigenous knowledge protection, and equitable technology design.
SDG 12	Encourages sustainable research practices and resource-efficient computing.
SDG 13	Enables climate modelling, environmental analytics, and sustainability-focused research.
SDG 15	Supports Indigenous ecological knowledge, biodiversity studies, and environmental monitoring.
SDG 16	Reinforces ethical research, transparency, and responsible knowledge creation.
SDG 17	Encourages collaboration with communities, industries, research labs, and Indigenous groups.

KISS

KALINGA INSTITUTE OF SOCIAL SCIENCES

KALINGA INSTITUTE OF SOCIAL SCIENCES (KISS)

DEEMED TO BE UNIVERSITY

Higher Education Campus, KISS Campus-3, Bhubaneswar, Odisha, 751024
https://university.kiss.ac.in | https://kiss.ac.in