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ताळगांव पठार
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(Accredited by NAAC)

GU/Acad –PG/BoS -NEP/2023/206 Date: 17.07.2023

CIRCULAR

The approved Syllabus for Semesters I to X of the **Master of Science (Integrated) in Data Science** Programme governed under OB-32 is attached.

The Dean/ Vice-Deans of the Goa Business School, offering the **Master of Science (Integrated) in Data Science** Programme are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN VYAS LAWANDE
Digitally signed by ASHWIN VYAS LAWANDE
Date: 2023.07.17 14:03:59 +05'30'

(Ashwin Lawande)
Assistant Registrar – Academic-PG

To,

1. The Dean, Goa Business School, Goa University.
2. The Vice-Deans, Goa Business School, Goa University..

Copy to:

1. The Chairperson, Board of Studies in Data Science.
2. The Programme Director, M.Sc Data Science, Goa University.
3. The Controller of Examinations, Goa University.
4. The Assistant Registrar, PG Examinations, Goa University.
5. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

Goa University

M.Sc Integrated (Data Science / Decision Science / Computer Science / Economics) **Semester VII onwards specific to the Discipline Data Science for students opting for MSc Integrated (Data Science)**			
Semester I	**Credits**	**Semester II**	**Credits**
IMC- 101:Management Concepts and OrganisationBehaviour	4	IMC- 201:Business Analytics	2
IMC- 102:Environmental Studies	4	IMC- 202:Microeconomics	4
IMC- 103: Probability and Statistics - I	4	IMC- 203:Linear Algebra	4
IMC- 104: Programming in Python	6	IMC- 204:Algorithms and Data structures	6
IMC- 105: Soft Skills - I (Oral Communication)	2	IMC- 205:Probability and Statistics - II	4
IMC- 106: Perspective Building Course - I (Film Appreciation)	2	IMC- 206:Soft Skills - II (Written Communication)	2
	22		22
Semester III	**Credits**	**Semester IV**	**Credits**
IMC- 301:Marketing Analysis	4	IMC- 401:Machine Learning	6
IMC- 302:Deductive and Inferential Mathematics	4	IMC- 402: Data Modeling and Visualization	6
IMC- 303: Macroeconomics	4	IMC- 403: Linear Programming & Optimization	4
IMC- 304: Database Management Systems	6	IMC- 404: Econometrics I	4
IMC- 305: Soft Skills - III (Interview Facing Skills and Mock Interviews)	2	IMC- 405: Soft Skills IV (Public Speaking Skills)	2
IMC- 306: Perspective Building course - II (Character Development)	2	IMC- 406: Perspective Building Course - III (Music Appreciation)	2
	22		22
Semester V	**Credits**	**Semester VI**	**Credits**
IMC- 501: Computer Organization & Operating Systems	6	IMC- 601: Introduction to Data Science	6
IMC- 502: Programming in C++	6	IMC- 602: Big Data Framework	6
IMC- 503: Data Science Toolkit	4	Elective 1 – one to be opted from the list of electives: IMC- 610 / IMC- 611 / IMC- 710 to IMC- 717	4
IMC- 504: Strategic Management	4	Elective 2 – one to be opted from the list of electives: IMC- 610 / IMC- 611 / IMC- 710 to IMC- 717	4
IMC- 505: Econometrics II	4	IMC- 651: Project Work OR IMC- 652: Internship	6

IMC- 506: Perspective Building Course - IV (Leadership)	2		
	26		26
Semester VII (Discipline Data Science)	**Credits**	**Semester VIII(Discipline Data Science**	**Credits**
IMC- 701: AI - Search Methods and Problem Solving	6	IMC- 801: Reinforcement Learning	4
IMC- 702: Research Methodology and IP	4	IMC- 802: Optimization Techniques for Analytics	6
IMC- 703: Deep Learning	6	IMC- 803: MLOps at scale	6
IMC- 704: Design thinking for Data Driven App development	4	Elective 4 one to be opted from the list of electives: IMC- 710 to IMC- 717 or IMC- 910 to IMC- 915	4
Elective 3 one to be opted from the list of electives: IMC- 710 to IMC- 717 or IMC- 910 to IMC- 915	4	Elective 5 one to be opted from the list of electives: IMC- 710 to IMC- 717 or IMC- 910 to IMC- 915	4
	24		24
Semester IX (Discipline Data Science)	**Credits**	**Semester X (Discipline Data Science)**	**Credits**
Elective 6 one to be opted from the list of electives: IMC- 710 to IMC- 717 or IMC- 910 to IMC- 915	6	IMC- 1051: Dissertation **OR** IMC- 1052: Internship	16
Elective 7 one to be opted from the list of electives: IMC- 710 to IMC- 717 or IMC- 910 to IMC- 915	6		
Elective 8 one to be opted from the list of electives: IMC- 710 to IMC- 717 or IMC- 910 to IMC- 915	4		
	16		16
TotaL Credits (5 years) = 220			

Name of the Programme: MSc Integrated
Course Code: IMC- 101
Title of the Course: Management Concepts and Organisational Behaviour
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Same as programme pre-requisites.	
Objective:	At the end of the course, the student should have the ability to understand managerial processes and have the competence to deal with people at work-place	
Content:	Management Science: basic concepts and its role in decision making: Planning, organizing, staffing, leading and controlling. Organization Structure and Design: Role in Individual and Interpersonal behavior at work-place	8 hours
	Introduction to Determinants of Individual Behaviour: Perception, Personality, Attitudes, , learning, Self- Concepts ; Theories/ Models for understanding these determinants	4 hours
	Fundamentals of Interpersonal Behaviour: Group Dynamics, Tools for Interpersonal Analysis, Fundamentals of Leadership and Motivation and their application, Theories/ Models/ Styles	15 hours
	Organizational Change and Development; Models of Change;	15 hours
	Organizational Climate and Culture; Conflict, and Negotiations. Power and Politics in Organization.	6 hours
Pedagogy:	Lectures/ tutorials/laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/ term papers/ assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/ Readings	1. Weihrich, Heinz and Harold Koontz; 'Essentials of Management: An International Perspective'; McGraw–Hill, Inc.; 10th edition, 2015 2. Robbins, Stephen and Mary Coulter; 'Fundamentals of Management'; Prentice Hall of India Pvt. Ltd.; New Delhi; 9th edition, 2018 3. Luthans, Fred; 'Organizational Behavior'; McGraw– Hill, Inc, 12th edition, 2017 4. Robbins, Stephen P; 'Essentials of Organizational Behavior'; Pearson Education India, 18th edition, 2018.	
Course Outcomes	1. Understand key management concepts: Students will grasp fundamental management principles such as planning, organizing, leading, and controlling. 2. Analyze organizational behavior: Students will examine individual and group behavior, including factors influencing motivation, job satisfaction, and the impact of culture and leadership. 3. Apply management principles: Students will apply management theories to practical situations, proposing strategies and making informed decisions. 4. Enhance interpersonal and leadership skills: Students will develop effective communication, collaboration, teamwork, and leadership abilities in diverse organizational settings.	

Name of the Programme: MSc Integrated
Course Code: IMC- 102
Title of the Course: Environmental Studies
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Nil	
Objective:	The course envisages that all the under graduates coming out of our University system are aware of our natural resources, ecosystems and their linkages to society, livelihood, environment and conservation. This theoretical learning shall be supported by the actual field visits.	
Content:	**Unit 1: The Multi-Disciplinary Nature of Environmental Studies** Definition, Scope and Importance; Components of environment; multidisciplinary nature of environmental studies;need for public awareness. **Unit 2: Natural Resources:** Renewable and Non-Renewable resources: natural resources and associated problems a) Forest Resources: use and over-exploitation, deforestation, case studies. Timber extraction, mining, dams and their effects on forests and tribal people. b) Water Resources: use and over-exploitation of surface and ground water; floods, droughts, conflicts over water, dams-benefits and problems. c) Mineral Resources: use and exploitation, environmental effects of extracting and using mineral resources; case studies related to mining and its effect on siltation and loss of biodiversity. d) Food Resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity; case studies. e) Energy Resources: growing energy needs, renewable and non-renewable energy sources, use of alternative energy sources, case studies f) Land Resources: land as a resource, land degradation, man-induced landslides, coastal erosion, soil erosion and desertification. • Role of an individual in conservation of natural resources. • Equitable use of resources for sustainable lifestyles. **Unit 3: Ecosystems** Concept of an ecosystem, structure and functions of ecosystems; producers, consumers and decomposers, energy flow in the ecosystem, ecological succession, food chains, food webs and ecological pyramids. Introduction, types, features, structure and functions of the following ecosystems: forest ecosystem, grassland ecosystem, desert ecosystem, aquatic ecosystem (ponds, streams, lakes, rivers, oceans, coastal zone, estuaries).	3 hours 8 hours 7 hours

	Unit 4: Biodiversity and its Conservation Introduction, definition, genetic, species and ecosystem diversity; bio-geographical classification of India; value of biodiversity - consumptive use, productive use, social, ethical, aesthetic and option values; biodiversity at global, national, regional and local levels; India as a mega-diversity nation; hotspots of biodiversity; threats to biodiversity - habitat loss, poaching of wildlife, man-wildlife conflicts, bio-invasion, and over exploitation; endangered and endemic species of India (at least 5 examples of animals and plants each); conservation of biodiversity- in-situ and ex-situ conservation, role of biotechnology in conservation of biodiversity.	8 hours
	Unit 5: Field visit to different ecosystems/Landscapes and to learn biodiversity Visit to a local area to document environmental assets - river/ forest/ grassland/ hill/ mountain; study of common plants, insects, birds; study of simple ecosystems- pond/ river/ hill slopes, etc. A report of field visit(s) to be maintained.	6 hours
	Unit 6: Environmental Pollution Definition, causes, effects and measures to control air pollution, water pollution, soil pollution, marine pollution, noise pollution, thermal pollution, nuclear hazards; waste – types, causes, effects; waste management –solid, sewage and effluents; measures to control industrial and urban wastes; role of an individual in prevention of pollution; pollution case studies (Bhopal gas tragedy and mining); disaster mitigation and management-floods, droughts, earthquakes, landslides, cyclones, Tsunami.	8 hours
	Unit 7: Social issues and the Environment From unsustainable to sustainable development; urban problems related to energy; water conservation, rainwater harvesting, watershed management; resettlement and rehabilitation of people - problems and concerns, case studies; environmental ethics - issues and concerns; climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust, case studies; wasteland reclamation; consumerism and associated waste products; Objectives and scope of Environment (Protection) Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and Control of Pollution) Act, Forest Conservation Act, Wildlife Protection Act, Forest Rights Act and Biodiversity Act; Issues involved in enforcement of environmental legislation; public awareness.	8 hours
Pedagogy:	Class lectures, Case Studies, Field visits	
References/ Readings	1. Agarwal K.C. (2001): Environmental Biology, Bikaner, Nidi 2. Bharucha E.: The Biodiversity of India, Ahmedabad, Mapin	

	3. Bharucha E.: Textbook of Environmental Studies. Orient BlackSwan 4. Chatwal G.R. & Sharma H. (2005: A Textbook of Environmental Studies, Mumbai, Himalaya 5. Cunningham W.P., Cooper T.H., Gorani E. & Hepworth M.T. (2001): Environmental Encyclopaedia, Mumbai, Jaico. 6. Desai R.J. (2003): Environmental Studies, Mumbai, Vipul 7. Hawkins R.E.: Encyclopaedia of Indian Natural History, Mumbai, BNHS 8. Heywood V.H. & Watson R.T. (1995): Environment Protection and Laws, Mumbai, Himalaya 9. Jadhav H. & Bhosale V.M. (1995): Environment Protection and Laws, Mumbai, Himalaya 10. McKiney M.L. & Schoel R.M. (1996): Environment Science, Systems and Solutions, Web Enhanced Edition. 11. Miller T.G. Jr.: Environmental Science, Wadsworth 12. Odum E.P. (1971): Fundamentals of Ecology, Philadelphia, W.B. Saunders 13. Rao M.N. & Datta A.K. (1986): Waste Water Treatment, Oxford & IBH 14. Santra S.C. (2004): Environmental Science, Kolkata, Central Book Agency **Magazines** Down to Earth, Centre for Science & Environment Survey of the Environment published by The Hindu.
Course Outcomes	Students will have the ability to 1. Distinguish between renewable and non-renewable resources 2. Understand different ways to manage resources sustainability 3. Appreciate the value of bio-diversity and its management

Name of the Programme: MSc Integrated
Course Code: IMC- 103
Title of the Course: Probability and Statistics - I
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Same as programme pre-requisites	
Objectives:	This course aims to introduce the basic concepts of probability theory	
Content:	**Module**	
	1. Experiments and sample spaces, events, algebra of events, probability axioms, conditional probability, independence of events, mutually exclusive events. Bayes theorem.	12 hours
	2. One dimensional random variable: discrete and continuous random variable, characteristics of distributions, cumulative distribution function, functions of one random variable.	12 hours
	3. Two dimensional random variable: marginal and conditional distributions, conditional expectation independence.	12 hours
	4. Covariance and correlation. Understanding linkages, visualizing	5 hours
	5. Discrete distributions: Bernoulli, Binomial, Poisson	7 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/ Readings	1. William W. Hines and Douglas C. Montgomery, Probability and Statistics in Engineering and Management Science, Wiley India Pvt. Ltd., 2003 2. T.Veerarajan, Probability, Statistics and Random Processes, Tata McGraw Hill Pub. Co. Ltd., 2009	
Course Outcomes	1. Understand fundamental probability concepts, including sample space, events, probability axioms, and conditional probability. 2. Apply probability rules and techniques to solve problems, including calculating probabilities, using counting principles, and working with discrete and continuous probability distributions. 3. Analyze and interpret data using probability concepts, including modeling random processes, conducting hypothesis tests, and making predictions based on probability models. 4. Apply probability in decision-making under uncertainty, including understanding concepts like expected value, risk, and utility, and using decision-making tools such as expected utility theory and decision trees.	

Name of the Programme: MSc Integrated
Course Code: IMC- 104
Title of the Course: Programming in Python
Number of Credits: 6(4L-0T-2P)
Effective from AY: 2020-21

Prerequisites for the course:	Same as programme pre-requisites	
Objectives:	The aim of the course is to provide an exposure to solve common computing problems through programming using Python language. The course is designed with a lab component to give the student hands-on experience of the basic concepts of programming.	
Content Theory:	Introduction to computer systems and data representation: Functional units of a Computer, Characteristics of a Computer, Data representation and Storage,Evolution of Programming Languages, Compilation and Interpretation, Structured and Procedural Programming languages	3 hours
	The Problem Solving Process: – Requirement Analysis, Algorithmic Construction, Identifying Test Cases, Desk Checking, Implementation, Testing and maintenance issues, Data verification and validation.	4 hours
	Python Programming Environment: Python overview, Structure of Python program, character Set, variable declarations and data types, Program Statements, Types of Instructions, Expression Evaluation rules, Type Conversions. Managing I/O operations	4 hours
	Selection and Iterative Constructs: Writing conditions, IF-ELSE constructs Conditional operators, SWITCH,WHILE and FOR loops, Use of BREAK and CONTINUE statements. Nested Loops	9 hours
	Advance Data types: Lists, Tuples, Set, Dictionaries, Strings, Unicode, formatting strings, docString. Searching and sorting algorithms without using library functions.	6 hours
	Modular Programming: Importance of User Defined Functions, Hierarchy charts, fan-in/out, cohesion and coupling and loosely coupled modules. Fan-in – Fan-out concepts.	5 hours
	User Defined Functions: Local and Global Variables, Scoping Rules, Parameters& arguments. Function with variable arguments. Modules, packages, scope. Recursion & Recursive Functions. Recursive v/s Iterative Functions.	7 hours
	Custom Data Types and File Management: Object of a Class and basic concept of classes & OOP, Files, Exceptions in file handling.	4 hours
	Introduction to Packages: Python packages for plotting, mathematical computation& linear regression.	6 hours
Content Practical:	Suggested Lab Assignments: minimum 16 assignments and duration of carrying out each assignment 3 hrs. 1. Introduction to UNIX environment- Introduction to Fedora/Ubuntu, Basic directory and file handling commands, Editor (vi editor), man pages, installation of Python and Jupyter notebook. Programs using decision control, branch and loop control structure 1. Program to find the largest of three numbers 2. Program to print the reverse of a given number. 3. Program to check whether a given number is Armstrong or not	16 * 3 = 48 hours

	4. Program to print the prime numbers from 2 to n, where n is an input given by the user. 5. Program to print the patterns. Programs using List, Set, Tuple, Dictionary & Strings 6. Program to find the largest and smallest number in a list of integers (without using library function). 7. Program to sort a given integer list in ascending order (without using library function). 8. Program to print the sum and average of the elements of the list (without using library function). 8. Program to find the duplicate elements in the list (without using library function). 9. Program to reverse a given string and check whether it is palindrome (without using library function). 10. Program to read a string and count the number of vowels in it. 11. Program to concatenate two strings without using library functions 12. Program to arrange the list of names in alphabetical order. 13. Program to find the union, interaction and difference between two sets. 14. Program to take a sentence as an input from the user and compute the frequency of each letter. Make use of dictionary type to maintain the count. 15. Programs using functions & Recursion. 16. Write functions for addition, subtraction and multiplication of two matrices. Each function has two matrices as parameters and returns the result. 17. Program to print the Fibonacci series using recursion. 18. Program to find the GCD of two numbers using recursion. 19. Program to solve Tower of Hanoi Programs user-defined data types & file handling 20. Program to store the item number, name, rate and quantity of 'n' items in a custom data type, where n is given as input by the user. Display the total value inventory items. 21. Program to store employee details in a Custom data type. The data should include employee ID, name, salary, and date of joining. The date of joining should be stored in a structure. The program should perform the following operations based on a menu selection a) Display the details of the employees who have more than 5 years of experience with the company. b) Increase the salaries according to the pay scale rules 22. Program to create a custom data type of Student with fields Roll No, Name, course, and Total Marks. Read the data from the user and store them in a file. Write a function to display the Roll No, name of the student who has secured the highest marks. 23. Program to count the number of characters in a file. 24. Program to search for a particular word in a file. 25. Program to handle various file exceptions. 26. Program to implement linear regression method. 27. Program to plot graphs.	
Pedagogy:	Lectures/Practical/ tutorials/assignments/self-study.	

References/ Readings	1. Taneja Sheetal, Kumar Naveen , —Python Programming - A modular approach, Pearson 2017 2. Guttag John V., —Introduction to Computation and Programming using Python, MIT Press, 2nd Edition 2016. 3. Maureen Sprankle, Jim Hubbard — Problem Solving and Programming Concepts, Pearson, 9th Edition 2012
Course Outcomes	1. Analyze a given problem and develop a Python program to solve it. 2. Identify test cases for a given problem. 3. Understand, test, trace programs written in Python language. 4. Working with python Standard Libraries,User Defined Functions,Custom Data Types and File Management and Packages

Name of the Programme: MSc Integrated
Course Code:IMC- 105
Title of the Course: Soft Skills - I (Oral Communication)
Number of Credits: 2(2L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Same as programme pre-requisites	
Objective:	To introduce the essentials of effective communication in different contexts	
Content:	Difference between formal and informal communication; Communication process, types, Effectiveness in communication – the Roles of Sender, Receiver and the medium; Role of culture in communication; cross cultural communication; Non Verbal Communication – aspects and importance.	12 hours
	Oral Communication: Skills required for effective interpersonal and group communication, Effective Public speaking. Noise in communication and its prevention. Barriers and Gateways in Communication;	12 hours
Pedagogy:	Lectures/ tutorials/laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Course Outcomes	1. Develop effective verbal communication skills, expressing ideas clearly and confidently. 2. Improve presentation and public speaking skills, delivering engaging and informative presentations. 3. Enhance active listening skills, understanding and interpreting verbal and non-verbal cues. 4. Adapt communication to different contexts, effectively communicating in various professional and social settings.	
References/ Readings	1. Business and Professional Communication by Kelly M. Quintanilla and Shawn T. Wahl, 2018, Sage Publications 2. Effective Business Communication by AnjaneeSethi ,BhavnaAdhikari, 2009; Tata MacGraw Hill Education, India. 3. How to be a Great Communicator in Person, On Paper, and onPodiumbyNidoQubein, 2008; Viva Books, India.	

Name of the Programme: MSc Integrated
Course Code:IMC- 106
Title of the Course: Perspective Building Course-I (Film Appreciation)
Number of Credits: 2(2L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course	Same as programme pre-requisites	
Objective:	To help the participants appreciate cinema (national and international) as having its own distinct language and philosophy, the way it stimulates people, and helps in making sense of the world.	
Content:	**Approaches to Films** Document, Documentary and Narratives; Thought Orientation in Films; Text, Context and Non-Text	6 hours
	Film and Other Art Forms Photography and Representation; Symbolism and Metaphors; Music, Dance and Drama; Presenting Reality and Fiction	6 hours
	Films and our Minds Films and Emotions; Imagination; Identifying the Audience (Spectatorship); Communication and Persuasion	6 hours
	Films and Morality Lessons from Films; Authorship and Copyright; Film Criticism; Evils and Issues – Pornography, Free Will, Laws and Artistic License	6 hours
Pedagogy:	Lectures/ tutorials/laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Course Outcomes	1. Gain a comprehensive understanding of film as an art form, including its history, genres, and technical aspects. 2. Analyze and interpret films critically, considering elements such as narrative structure, visual composition, and symbolism. 3. Explore cultural and social perspectives in films, examining diverse viewpoints and addressing relevant social issues. 4. Develop effective communication skills to discuss and write about films, expressing opinions and engaging in meaningful discussions.	
References/ Readings	1. Jim Piper (2014) The Film Appreciation Book, 1st Edition; Allworth Publishers, USA 2. Satyajit Ray (2006) Speaking of Films, International Edition Penguin, India 3. Gregory Currie (1995) Image and Mind, Film, Philosophy and Cognitive Science; Cambridge University Press.	

Name of the Programme: MSc Integrated
Course Code: IMC- 201
Title of the Course: Business Analytics
Number of Credits: 2(2L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course	Nil	
Objective	To introduce fundamentals of financial management	
Content	Reading of Annual Report, Balance Sheet, Profit and Loss Account, Vertical Form, Cash Flow statements, Comparative statements, Common Size Statements, Profitability Ratios. Basic Accounting Standards. Directors" Report, Auditor's Report, Notes to Accounts,	8 hours
	Understanding Annual Reports of Companies with Ratio Analyses and making basic performance decisions.	8 hours
	Time Value of Money, Forecasting cash flows, Estimation of Project Cost, Techniques of Capital Budgeting, N. P. V., I. R. R., Discounted Payback, profitability Index.	8 hours
Pedagogy	Lectures/tutorials/laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. Or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Course Outcomes	1. Understand the fundamentals of business analytics and its role in decision-making. 2. Analyze and interpret data using various analytical tools and techniques. 3. Apply quantitative models and techniques to solve business problems. 4. Communicate analytical findings and insights effectively.	
References/ Readings	1. N. Ramchandran, Ram Kumar Kakani: How to Read A Balance Sheet", Tata McGraw-Hill Professional: Finance Made Easy Series,2009. 2. N. Ramchandran, Ram Kumar Kakani: „How to Read A Profit and Loss Account", Tata McGraw-Hill Professional: Finance Made Easy Series, 2017 3. N. Ramchandran, Ram Kumar Kakani: „How to Read A Cash Flow Statement", Tata McGraw-Hill Professional: Finance Made Easy Series, 2017	

Name of the Programme: MSc Integrated
Course Code: IMC- 202
Title of the Course: Microeconomics
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the Course:	Nil	
Objective:	Equip the students to understand consumer and firm behavior under profit and non-profit maximizing framework.	
Content:	**Module 1: Introduction and Basic Concepts** Nature and scope of micro economics – concept of equilibrium – static, dynamic and neutral equilibrium – Partial Vs. General equilibrium – role and limitations of price mechanisms in a free market economy **Module 2: Theory of Demand** Theory of Consumer Behavior- Utility, indifference curve, [income and substitution effects, Slutsky‟s theorem, compensated demand]; Revealed preference; consumer surplus; **Module 3: Theory of production and costs** Production function –short period and long period; law of variable proportions and returns to scale; Isoquants – least cost combination of inputs; Returns of factors; Economies of scale; Elasticity of substitution; Euler‟s Theorem; Cobb-Douglas, CES, VES and Translog. Cost functions, cost curves, Elasticity of supply. **Module 4: price and output determination** Demand and supply equilibrium; Cobweb theorem. Market forms – perfect and imperfect forms – equilibrium under perfect, monopoly, monopolistic, duopoly and oligopoly – importance of time element in price theory – price discrimination and measure of monopoly power – control and regulation of monopoly.	10 hours 14 hours 14 hours 10 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
Reference/ Readings:	1. Varian, Hal R., *Intermediate Microeconomics*, Current Edition, W.W. Norton and Company 2. Andreu Mas-colell, Michael D. Whinston and Jerry R. Green John, *Microeconomic Theory*, Oxford University Press, Current Edition.	
Course Outcomes:	1. Understand basic economic principles and concepts. 2. Analyze market behavior and outcomes in different market structures. 3. Apply economic models to real-world situations. 4. Understand the implications of microeconomic policies.	

Name of the Programme: MSc Integrated
Course Code: IMC- 203
Title of the Course: Linear Algebra
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Standard XII mathematics	
Objectives:	The aim of this course is to provide students an introduction to vectors and matrices and their use in Data Sciences.	
Content:	Linear Equations in Linear Algebra: Systems of linear equations, row reduction, and echelon forms, Vector equations, matrix equation, solution sets of linear systems, linear independence, Matrix of linear transformation.	8 hours
	Matrix Algebra: characteristics of invertible matrices, Partitioned matrices, matrix factorizations, application to computer graphics, dimension and rank.	4 hours
	Determinants: Properties, Cramer‟s rule, volume and linear transformations.	4 hours
	Vector Spaces: vector spaces and subspaces, linear transformations, Bases, coordinate systems, Dimension of a vector space, rank, change of bases	8 hours
	Eigenvalues and eigenvectors: Characteristics equation, diagonalization, eigenvectors and linear transformations, discrete dynamical systems	8 hours
	Orthogonality: inner product, length, and orthogonality, orthogonal sets, orthogonal projections, Gram-Schmidt process, inner product spaces	8 hours
	Symmetric matrices and quadratic forms: diagonalization of symmetric matrices, quadratic forms, constrained optimization, Singular Value Decomposition (SVD).	8 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/ Readings:	1. David C. Lay, Linear Algebra and its Applications, Pearson. 2. Jim DeFranza and Daniel Gagliardi, Introduction to Linear Algebra with Application, McGraw Hill Education (India) 3. Steven J. Leon, Linear Algebra with Applications 8th Edition, Pearson. 4. Gilbert Strang, Introduction to Linear Algebra 4th Ed. South Asian Edition, Wellesley-Cambridge Press	
Course Outcomes:	1. Develop a strong foundation in linear algebra concepts and techniques. 2. Solve linear systems and matrix equations. 3. Perform vector and matrix operations proficiently. 4. Apply linear algebra in various disciplines and real-world contexts.	

Name of the Programme: MSc Integrated
Course Code: IMC- 204
Title of the Course: Algorithms and Data Structures
Number of Credits: 6(4L-0T-2P)
Effective from AY: 2020-21

Prerequisites for the course:	Programming in Python	
Objectives:	The aim of the course is to introduce the fundamental concept of data structures and to emphasize the importance of data structures in developing and implementing efficient algorithms. It provides an exposure to various data structures and algorithm analysis including lists, stacks, queues, trees, and various sorting and searching algorithms.	
Content Theory:	Introduction: Three level Approach - Application/User level, Abstract/Logical level, Physical/Implementation level; Concept of Abstract Data Types (ADTs), Data Structure definition, Data type vs. data structure, Applications of data structures,	4 hours
	Algorithms analysis and its complexity, Best case, worst case , and Average case performance, time-space tradeoff, Asymptotic Analysis, Big-O notation.	4 hours
	Linear Data Structures: Array and its application: Polynomials, Sparse matrices, String-pattern Matching. Linked Lists, Doubly linked list, Circular linked list, Stack and Queues.	10 hours
	Nonlinear Data Structures: Trees: Binary tree representation, Binary Search Trees, AVL Trees, M-way Search Trees, B-trees. B tree algorithms, Heap Structures.	10 hours
	Graphs: Graph representations; Graph Traversals	2 hours
	Complexity of Searching & Sorting algorithms: Bubble sort, Quick sort, Selection sort, Insertion sort, Merge sort and Heap sort. An Empirical Comparison of Sorting Algorithms, Lower bounds for Sorting. Linear search, binary search.	12 hours
	Dynamic programming and Greedy algorithms: Assembly line scheduling, Matrix-chain multiplication; Prim‟s Algorithm, Kruskal‟s Algorithm	6 hours
Content Practical:	**Suggested Lab Assignments: minimum of 16 assignments with duration of 3 hrs for each assignment** Object-Oriented Design Goals, Object-Oriented Design Principles. 1. The programming assignment should introduce and enforce the concepts of encapsulation, polymorphism and Inheritance. ADT Specifications and Implementation of following basic data structures 1. Singly Linked Linear Lists 2. Singly Linked Circular Lists 3. Doubly Linked Linear Lists 4. Doubly Linked circular Lists 5. Stack using linked list 6. Queue using linked list ADT Specifications and Implementation of following non-linear data structures 1. Binary Trees	16 * 3 = 48 hours

	2. Binary Search Trees 3. AVL Trees 4. B-Trees and its variants Application of stack 1. Program to convert the given infix expression to postfix expression using stack. 2. Program to evaluate a postfix expression using stack. 3. Program to traverse a binary tree in the following way: Pre-order, In-order, Post-order Applications of Binary Trees 1. Write a program to implement Huffman encoding using Binary tree. 2. Write a program to create a binary tree for the given infix expression. Applications of AVL Trees 1. Write a program that reads a list of names and telephone number from a text file and inserts them into an AVL tree. Write a function to allow the user to search the tree. Searching and sorting 2. Program to implement Binary search technique using Iterative method and Recursive methods. 3. Programs to implement following sorting algorithm- Bubble sort, Selection sort, Insertion sort, Quicksort, Merge sort and Heap sort Implementation of Dynamic programming 1. Assembly line scheduling 2. Matrix-chain multiplication Implementation of Greedy algorithms 1. Prim‟s Algorithm 2. Kruskal‟s Algorithm	
Pedagogy:	lectures/Practical/ tutorials/assignments/self-study	
References/ Readings:	1. Horowitz, Ellis, Sartaj Sahni, and Susan Anderson-Freed. Fundamentals of data structures in C. WH Freeman & Co., 1992. 2. Benjamin Baka, Basant Agarwal, “Hands on Data Structure and Algorithms with Python”, Second Edition, O‟Reilly, 2018 3. Cormen Thomas, L. Charles, R. Ronald, S. Clifford, “Introduction to Algorithms”, Second Edition,EEE, PHI. 4. Allen, Weiss Mark. Data structures and algorithm analysis in C. Pearson Education India, 2011. 5. Algorithms, by Dasgupta, Papadimitriou, and Vazirani, McGraw-Hill.	
CourseOutcomes:	1. Understand fundamental algorithms and data structures. 2. Analyze algorithm complexity and efficiency. 3. Design and implement efficient algorithms. 4. Apply data structures and algorithms in problem-solving.	

Name of the Programme: MSc Integrated
Course Code: IMC-205
Title of the Course: Probability & Statistics - II
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Nil	
Objectives:	This course aims to introduce the basic concepts of probability theory and statistical analysis. Students will get exposure to fundamental theory of distribution of random variables, the basic theory and techniques of parameter estimation and tests of hypotheses.	
Content:	**Module 1:** Continuous distributions: Uniform, exponential, normal, standard normal, T-distribution, Chi-Square and F distribution	12 hours
	Module 2: Sampling distributions, Parameter Estimation of mean and proportion.	12 hours
	Module 3: Hypothesis tests about mean and proportion, Chi square tests, analysis of variance, least squares curve fitting, the coefficient of Determination, Confidence Intervals	12 hours
	Module 4: Non parametric tests: sign test, Rank test, Median test	12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/ Readings	1. T.Veerarajan, Probability, Statistics and Random Processes, Tata McGraw Hill Pub. Co. Ltd. 2. P.S.Mann, Introductory Statistics, Wiley Student edition	
Course Outcomes:	1. Understand fundamental statistical concepts. 2. Analyze and interpret data using statistical techniques. 3. Apply statistical methods to real-world problems. 4. Critically evaluate statistical information.	

Name of the Programme: MSc Integrated
Course Code: IMC 206
Title of the Course: Soft Skills - II (Written Communication)
Number of Credits: 2(2L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Nil	
Objective:	To introduce the essentials of effective communication in different contexts	
Content:	Written Communication: Fundamentals of effective writing; different forms of written communication; report writing, creative writing; Structure and content of various types of reports; Creativity in Communication	12 hours
	Competitive versus collaborative communication, types of negotiation, barriers in effective negotiation, interests versus positions in negotiation;	12 hours
Pedagogy:	Lectures/ tutorials/laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
CourseOutcomes:	1. Develop effective written communication skills. 2. Write for different purposes and audiences. 3. Organize and structure written content. 4. Develop research and citation skills.	
References/ Readings:	1. Business and Professional Communication by Kelly M. Quintanilla and Shawn T. Wahl, latest Edition, Sage Publications 2. Effective Business Communication by AnjaneeSethi ,BhavnaAdhikari, Tata MacGraw Hill Education, India. 3. How to be a Great Communicator in Person, On Paper, and on PodiumbyNidoQubein, Viva Books, India.	

Name of the Programme: MSc Integrated
Course Code: IMC- 301
Title of the Course: Marketing Analysis
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Same as programme prerequisites	
Objective:	At the end of the course, the students would have competence in understanding and using Marketing Frameworks, Theories and analytical tools for analysing and decision making in the area of Marketing.	
Content:	Role of Marketing, Core Concepts of Needs, Wants and Demands, Marketing Orientation of Companies. Strategic Planning and Marketing Management Process. External Environment including Customers and Suppliers.	12 hours
	Consumer Behaviour and Consumer markets, Theories of Consumption Behaviour, Buying Process and decision making process. Types of Buying behavior. Organisational Buying behavior, Industrial Market, Reseller Markets, Government Markets.	6 hours
	Marketing Information Systems, concepts and components, Market Measurement and Forecasting techniques, Demand Estimation, Segmentation, Targeting and Positioning, Types of segmentation, Basis for Segmentation.	6 hours
	Marketing Plan, Process and evaluation, New Product Development Process, Product Life Cycle concept, different strategies of different stages of PLC, Strategies for Leaders, Followers, Challengers and Nichers.	6 hours
	Product Concept and hierarchy, Product decesions, Branding and Packaging Decisions, Pricing and setting of Price, Methods of Pricing and initiating responses to Price Cuts. Channels of Distribution, Role and Types of Channel, Distribution Channel design and management and modification. Retailing and Wholesaling. Advertising and Integrated Marketing Communication. Advertising decisions, Media decisions, Sales promotion concept and designing. Sales Management and Personal Selling. Digital Marketing and Social Media Marketing.	6 hours 6 hours
	Marketing Plan, Audits and Control of Marketing Decisions. Annual Plan Control, Profitability Control, Efficiency Control and Strategic Control.	6 hours
Pedagogy:	Pedagogy includes interactive sessions involving lectures, case studies, presentations, debates and field based work.	
Course Outcomes	1. Understand marketing research principles and methodologies. 2. Analyze marketing data using statistical techniques and software tools. 3. Apply market segmentation and targeting strategies. 4. Evaluate marketing campaigns and make data-driven recommendations.	
References/ Readings	1. Majarao, Simon; 'The Essence of Marketing'; Prentice Hall of India Limited; New Delhi; Latest edition. 2. Brand Equity and News Items of Economic Times, Articles from Popular Business Periodicals, etc. 3. Kotler, Philip., Keller Kevin., Koshy Abraham., and JhaMithileshawar; 'Marketing Management: A South Asian Perspective'; Pearson Education India, Latest edition. 4. Ramaswami., Namkumari; Marketing Management, McMilanIndiaLtd. New Delhi.	

	Latest Edition 5. Baines, Paul; Chris, Fill; Kelly, Page; Sinha, Piyush Kumar: Marketing Management; Oxford Press, India. Latest Edition.

Name of the Programme: MSc Integrated
Course Code: IMC- 302
Title of the Course: Deductive and Inferential Mathematics
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the Course:	XII Mathematics	
Objective:	On completion of this course, the learner should be able to successfully explore, conjecture and reason logically to arrive at a solution to a given problem using appropriate mathematical methods and will learn to estimate the impact of a policy/decision in the presence of uncertainty	
Content:	**Unit -1 :Mathematical Logic-**An open sentence, a closed sentence, Definition of proposition or a Statement. Strong emphasis on the Distinction between Inclusive OR and Exclusive OR. -In Logic, Mathematics and in Computer Science theory, **only inclusive OR** is used unless otherwise stated.-Logical Connectives - **NOT(negation** $\neg$ $\sim$)-**AND (conjunction** $\wedge$**)**, **OR (disjunction** $\vee$**),IF…THEN**(one way implication $\Rightarrow$ $\rightarrow$) and **IF,AND ONLY IF** (two ways implication $\Leftrightarrow$ $\leftrightarrow$) Truth tables for each one of the above.-Compound Proposition. Technique of determining the Truth value of a compound proposition using the truth tables and without using the truth tables.-Equivalent statements ($\equiv$.). Examples and important logical results. De Morgan Laws for negation.Converse, Inverse and Contra positive of conditional proposition. Tautology and Contradiction. Definition and Examples. Functionally complete set of connectives.OtherConnectives such as XOR($Exclusive\ OR$: ∇ **),** NAND (Not and : $\uparrow$**)** and NOR (Not or : $\downarrow$)Both NAND and NOR singly form a functionally complete set of connectives by deriving that all other connectives can be expressed exclusively in terms of only NAND or NOR. How the proof by contradiction works: p $\Rightarrow q \equiv \sim q \Rightarrow \sim p$ -Meaning of some as at least one. **Unit 2-Well-formed-formulae** . Equivalence of formulae. Various laws governing the well-formed formulae. Duality law. Normal Form. Disjunctive normal form, conjunctive normal form, Principal disjunctive normal form, Principal conjunctive normal form. Propositional Calculus. Predicate Calculus. Predicate Formula. Equivalence of Predicate Formulae. Inference Theory. **Unit -3 :SET THEORY:** (Quick revision and recapturing) Definition. Different ways of expressing a set such as Set Builder Method, Venn Diagram, Roster Method. Equality of two sets. Different types of sets. Empty set, Universal set, Finite Sets, Infinite Sets, Universal Sets etc. Proper emphasis on explaining the Universal Set. Set Operations such as Union, Intersection, Complementation, Set Theoretical Difference. Their properties. De Morgan Laws for the complementation.	5 hours 5 hours 5 hours

	Comparison of sets through subset, super set. Properties. Set Identities. Sets of Natural Numbers, Integers, Rational Numbers, Real Numbers and relation among them. Mathematical Induction. Functions: Relation on sets. Definition of a function as a relation. Domain, Co-domain and the range of a function. One-to-one (injective), Onto (surjective) One-to-one and Onto (bijective) functions. Composition of functions. Various properties of composition of functions with composition as an operator on the set of all functions with common domain and co-domain. Inverse of a function. Condition for existence of an inverse of a function. Uniqueness of the inverse. Properties of inverses of functions.	
	Unit 4 :- Counting Principle. **Principle of Inclusion and Exclusion:** Counting the number of elements in the union of finitely many finite sets in terms of the number of the elements of the individual sets and the number of elements of possible intersections of the sets involved. Principle of inclusion and exclusion for finitely many finite sets.	5 hours
	Unit - 5:- Inferential Statistics Introduction to Probability Theory using Kolmogorov Technique: Definition of an experiment. Outcomes of an experiment. Outcomes which are not **decomposable**. Sample space as the set of all **non-decomposable** outcomes of an experiment. Event as any subset of the sample space of an experiment under consideration. Probability of an event. Laws of probability. Exclusive events and Independent events. Conditional Probability. Extension of conditional probability. Revision of Permutations and Combinations. Stress on solving problems in obtaining permutations and combinations when the elements are repeated. (For the topic of combination of repeated elements, refer Discrete Mathematics by Kenneth Rosen) Idea of variations. Standard deviation as the root mean square deviation with respect to the mean. Mathematical Expectation and Expected Values. Random Variables: Idea of Distribution of a Function. Some standard Distributions such as Binomial., Normal, Poisson and Exponential. Their standard properties with the stress on Normal Distribution. Use of Normal Distribution Table to solve problems.	8 hours
	Unit - 6 :- Sampling Techniques Testing Statistical Hypothesis. Parameters are statistical constants such as Mean, Variance etc. In sampling techniques, **Statistics** are the parameters estimated (of the population) from the samples drawn from the population. Clear distinction to be made between the **parameters** and **statistics.** Standard Error is the standard deviation of the sampling distribution of the statistics. Null Hypothesis and Alternate Hypothesis. Critical Region and Intervals of confidence, the Level of Significance.	5 hours

	Errors in Sampling: Type I and Type II errors. One tailed and two tailed tests. **Unit - 7 :- Tests of Significance for the large Samples:** i) Testing Significance of single proportion ii) Testing Significance of for the difference of proportions of two large samples iii) Test of Significance for single Mean iv) Test of Significance for Difference of Means of two large samples Tests of Significance for the small Samples (using Student t-test) Concept of t-distribution. Degree of freedom. **Unit -8 :-Tests of Significance of Large Samples:** (i) Testing Significance of single proportion (ii) Testing Significance of for the difference of proportions of two small samples (iii) Test of Significance for single Mean (iv) Test of Significance for Difference of Means of two small samples. **Unit-9:- Resampling Techniques:** Resampling. Need for carrying out resampling. Advantages. Some selected methods of resampling: a) Bootstrapping and Normal Resampling, b) Permutation Resampling c) Cross Validation	5 hours 5 hours 5 hours
Pedagogy	Assignments/Presentations	
Reference/ Readings	1. A textbook of Discrete Mathematics by Dr. S. K. Sarkar S, Chand & Company, New Delhi. 2. Discrete Mathematics and its Applications by Kenneth Rosen, Tata McGraw Hill. 3. Discrete Mathematics for Computer Scientists by John Truss, Addison Wesley (Pearson Education). 4. Discrete Mathematics and Graph Theory by Purna Chandra Biswal, Prentice Hall of India. 5. Statistics for Management by Richard Levin and David Rubin, Prentice Hall of India. 6. Statistics for Business and Economics by Anderson, Sweeney and Williams, Thomson South Western. 7. Statistics for Management by Anand Sharma, Himalaya Publishing House, Mumbai. 8. Engineering Mathematics Volume II by Kandasamy, Tilagavathy and Gunavanthy S. Chand & Company, New Delhi.	
Course Outcomes	1. Learner will understand how to explore, conjecture and reason logically to model/arrive at a solution to a given problem 2. Learner will be able to use a variety of mathematical methods effectively to solve problems 3. Learner will learn decision making in the presence of uncertainty 4. will learn to quantify the uncertainty in estimation /the decision	

Name of the Programme: MSc Integrated
Course Code: IMC- 303
Title of the Course: Macroeconomics
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Same as programme pre-requisites	
Objectives:	Provide a basic understanding of how aggregate variables like national income, aggregate prices, employment, and exchange rates get determined by interaction of public policy and individual agents	
Content:	**Module 1: Introduction to Macroeconomics :** What is it about**.** Aggregate Income and its Dimensions, Measuring output, Real and Nominal Incomes, Savings, Balance of Payments and the Money supply. The sources and Use of Savings, The Balance of Payments, The Money supply	10 hours
	Module 2: Consumption & Investment. Keynes on Consumption, Consumption Smoothing, Temporary and Permanent Shocks, Stochastic Income Expectations, Effect of Interest Rates, Aggregating Across Individuals, Savings and Portfolio Choice, Profit Maximization and the Optimal Capital Stock, Adjustment Costs and Investment Decisions, Financial Structure and Investment, Residential and Inventory Investment, Irreversibility and Investment, Investment in Developing Countries, Investment in India	14 hours
	Module 3: Trade Balance and Exchange rates, Demand for Money, Labour market. The Real Exchange Rate, Other Approaches to the Trade Balance, Exchange Rates and Assets, Purchasing Power Parity, Choice of Exchange Rate Regimes, Money, Bonds, and Private Wealth, Nominal and Real Interest Rates, Financial Assets and the Budget Constraint, Money as a store of value, Seigniorage, Profit Maximization and Labour Demand, Utility and Labour Supply, Aggregate Supply with / without Money illusion, Introducing Unemployment, Cyclical Unemployment and the Output Gap, The Static Phillips Curve, The Dynamic Phillips Curve	14 hours
	Module 4: IS-LM model : Walras Law, Nominal Versus Real Rate of Interest, The IS Curve, The LM Curve, IS and LM - Fiscal and Monetary Policy, IS - LM in India, Ricardian Equivalence– determination of equilibrium income and interest rates – fiscal and monetary policy.	10 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
References/ Readings	*Essential Reading* 1. Macroeconomics by Errol D'Souza, Pearson Education, Delhi Second Edition 2012 *Additional Reading* 1. Macroeconomics: Theories and Policies, by Richard T. Froyen, Pearson Education, 10th Edition or later, 2013	
Course Outcomes	1. Understand macroeconomic principles and concepts. 2. Analyze macroeconomic indicators and policies. 3. Apply macroeconomic models and theories. 4. Understand global and international macroeconomics.	

Name of the Programme: MSc Integrated
Course Code: IMC- 304
Title of the Course: Database Management Systems
Number of Credits: 6(4L-0T-2P)
Effective from AY: 2020-21

Prerequisites for the course:	Operating Systems, Data and File Structures, A programming language	
Objectives:	To Provide students with theoretical knowledge and practical skills to effectively design , implement and query a relational database application	
Content Theory:	**Basic concepts** Database & Database Users, Characteristics of the Database Approach, Database Systems, Concepts & Architecture Data Models, Schemes & Instances, DBMS Architecture of Data Independence, Data Base languages & Interfaces	6 hours
	Relational Model The Relational Model, Overview of Design Process, Data Modelling using the Entity – Relationship approach , Structure of Relational Databases, Relational Algebra	10 hours
	SQL-A Relational Database Language Data Data Definition in SQL, structure of SQL queries, Set operations, aggregate functions, Nested Subqueries, Modification of the database, Views Specifying Integrity Constraints & Indexes in SQL. A Relational Database Management System	12 hours
	Relational DataBase Design Features of a Good Relational design, Function Dependencies &Normalization , Normal forms based on primary keys (1NF, 2NF, 3NF, BCNF) Covers of Functional Dependencies, Canonical covers. Loss less join and Dependency preserving decomposition algorithms.	10 hours
	Transactions Concept and states of transactions, Properties of Transactions, issues in Concurrent execution of transactions, concept of serializability, Recovery techniques	10 hours
Content Practical:	**Suggested Lab Assignments:** • **Installation of DBMS Software**	
	A. Data Definition Language(DDL) Statements 1. Creating tables, with or without constraints. 2. Understanding Data types. 3. Creating User Defined data Types 4. Altering the structure of the table 5. Dropping tables. 6. CreatingSequences	6 hours
	B. Query in Data Dictionary 1. To view the structure of the table created by the user. 2. To view user information. 3. To view integrity constraints.	6 hours
	C. Data Manipulation Language(DML) Statements	6 hours

	1. Inserting Data into the table. 2. Updating Data into the table. 3. Deleting Data from the table. **D. Simple SQL statements** 1. Displaying all the attributes and tuples from the table. 2. Displaying selected attributes/tuples from the table. 3. Using Logical and comparison operators. 4. Ordering data **E. Complex SQL Statements** 1. Using aggregate functions (using Group by and having clauses). 2. Creating SQL Aliases and View. 3. Joins and Nested queries. 4. Creating temporary tables in SQL statements **F. Transaction Control Language(TCL) statements** **G. Embedded SQL statements** 1. Procedures with and without cursors	5 hours 5 hours 5 hours 5 hours
Pedagogy:	Lectures/ tutorials/assignments/class presentations and debates/peer reviews / workshops /self-study	
References/Readings	1. Korth, Silberchartz, " Database System Concepts" McGrawhill Publication. 2. Elmasri and Navathe, " Fundamentals of Database Systems", Addison Wesley, New Delhi. 3. Database Management Systems –R. Ramakrishnan, J.Gehrke – T.McGraw Hill 4. Desai B., " An Introduction to Database Concepts", Galgotia Publications, New Delhi. 5. Rob,Coronel, "Database Systems (Design, Implementation and Management)" 6. Date C. J. , " An Introduction to Database Systems", Publication House, New Delhi.	
Course Outcomes	1. Understand and evaluate the role of database management systems in information technology applications within organizations; 2. Recognise and use logical design methods and tools for databases and Implement a database solution to an information technology problem; 3. Understand the SQL data definition and SQL query languages and Develop sophisticated queries to extract information from databases. 4. Understand how the database manages and recovers from concurrent and multiple transactions	

Name of the Programme: MSc Integrated
Course Code: IMC- 305
Title of the Course: Soft Skills - III (Interview Facing Skills and Mock Interviews)
Number of Credits: 2(2L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course:	Same as programme prerequisites	
Objective:	To introduce the basics of writing resumes and preparatory skills required to face interviews	
Content:	Fundamentals of Resume Writing, Writing effective Cover letters and emails to organizations.	4 hours
	Group Discussions – different types, Different types of interviews and basic competencies required in facing interviews.	4 hours
	Preparation required prior to facing an interview – industry and firm analysis. SWOT analysis; Frequently asked questions in interviews	4 hours
	Mock interviews to assess conceptual clarity, domain knowledge, soft skills, and perspectives held, etc.	12 hours
Pedagogy:	Lectures/ tutorials/laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/ term papers/assignments/ presentations/ selfstudy/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning	
Course Outcomes	1. Develop effective communication skills for interviews. 2. Prepare thoroughly for job interviews. 3. Master interview techniques and respond confidently. 4. Demonstrate professionalism and leave a positive impression.	
References/Readings	1. Prasad, HariMohan,How to prepare for Group Discussion and Interview, Tata McGraw Hill, Latest Edition 2. Patnaik, Priyadarshini, Group Discussion and Interview Skills, Cambridge University Press, Latest Edition	

Name of the Programme: MSc Integrated
Course Code: IMC- 306
Title of the Course: Perspective Building course - II (Character Development)
Number of Credits: 2(2L-0T-0P)
Effective from AY: 2020-21

Prerequisites for the course	Same as programme prerequisites	
Objective:	Have a holistic outlook towards life, to face and solve the challenges in their day to day life by strengthening their Emotional intelligence. Using their Talents to develop their personality and using this to bring happiness in their life and career. Changing their behaviour by becoming passionate and positively energized in doing their studies, job and life.Help them to become productive, proactive and persevere in all that they do in their lives and to become good Managers and professionals	
Content:	Talents you are born with, using Talents to enhance your personality and succeed. Using the E – Enthusiasm. Using this to build your passion and positive Energy. E - Efforts – Persevere and reach your goals. In Efficiency - un Productive and not planned or not Pro active . Dealing with their negative Self Awareness, Self Regulation, Motivation, Empathy and Social Skill. E - Positive Emotional Intelligence to reach your goals. Negative Attitude with regards to oneself, family and Friends. Positive Attitude	4 hours 4 hours 4 hours 4 hours 4 hours 4 hours
Pedagogy:	Use of Presentations, Activities, Discussions	
Course Outcomes	1. To face and solve the challenges in their day to day life by strengthening their Emotional intelligence. 2. Using their Talents to develop their personality and using this to bring happiness in their life and career. 3. Change their behaviour by becoming passionate and positively energized in doing their studies, job and life. 4. Learn to use emotional intelligence skill in all walks of life.	
References/Readings	1. Rich Dad Poor Dad – Robert Kiyosaki . Warner books 2. Think and grow Rich – Napoleon Hill. The Ralston Society 3. The Power of now- Eckhart Tolle. Namaste Publishing	

Name of the Programme: MSc Integrated
Course Code: IMC- 401
Title of the Course: Machine Learning
Number of Credits: 6(4L-0T-2P)
Effective from AY: 2021-22

Prerequisites for the course:	Familiarity with linear algebra, statistics & probability theory	
Objectives:	This course provides students with an in-depth introduction to three main areas of Machine Learning: supervised and unsupervised and reinforcement learning.this course will cover some of the main models and algorithms for regression, classification, clustering and Markov decision processes. Topics will include linear and logistic regression, regularisation, SVMs and kernel methods, ANNs, clustering, and dimensionality reduction ,sequential learning Like HMM and deep learning CNN and RNN	
Content Theory:	**1. Introduction:** well posed learning problem, designing a learning system, perspectives and issues in machine learning- types of learning - supervised, unsupervised and reinforcement learning	3 hours
	2. Concept learning: concept learning task, notation, inductive learning hypothesis, concept learning as search, version space and candidate elimination algorithm, decision tree, random forest.	5 hours
	3. Linear regression: logistic regression-Support vector machine kernel, Model selection and feature selection-Ensemble methods: Bagging, boosting, Evaluating and debugging learning algorithms.	5 hours
	4. Continuous Latent Variables: Principal Component Analysis, Maximum variance formulation, Minimum error formulation, Applications of PCA, PCA for high-dimensional data.	5 hours
	5. Neural Networks: -Feed-forward Network, Functions, perception, -Weight-space symmetries, Network Training, Parameter optimization, Local quadratic approximation, Use of gradient information, Gradient descent optimization, Error Back propagation, Evaluation of error-function derivatives, Efficiency of back propagation.	10 hours
	6. Deep learning: Deep Feed forward Networks, Gradient-Based Learning, Hidden Units, -Architecture Design, CNN and RNN (simple RNN and LSTM).	5 hours
	7. Unsupervised learning; Clustering, K-means, EM. Mixture of Gaussians.	5 hours
	8. Sequential Data: Markov Models, Hidden Markov Models, Maximum likelihood for the HMM, The forward-backward algorithm, the sum-product algorithm for the HMM, Scaling factors, -The Viterbi algorithm.	5 hours
	9. Reinforcement learning: introduction- learning task-Q learning, non deterministic rewards and actions-temporal difference learning.	5 hours
Content Practical:	**Suggested Lab assignments/work with respect to the following using python (scikit /keras libraries) /amazon sage maker/matlab toolbox - each assignment with duration of 4 hrs and 8 hrs for project work** 1. Write a program to implement version space. 2. Write a program to implement a decision tree for given data. 3. Write a program to implement linear regression for given data. 4. Write a program to implement logistic regression. 5. Write a program to implement SVM.	10 * 4 = 40

	6. Write a program to implement perceptron. 7. Write a program to implement a multilayer perceptron. 8. Write a program to implement RNN. 9. Write a program to implement CNN. 10. Write a program to implement HMM. Capstone mini project work is given to assess the overall learning.	hours + 8 hours Mini Project Work = 48 hours
Pedagogy:	lectures/ tutorials/assignments/self-study/lab assignment/ project work	
References/ Readings	Main Reading :- 1. James, Gareth, et al. An introduction to statistical learning. Vol. 112. New York: springer, 2013. 2. Alpaydin, Ethem. Introduction to machine learning. MIT press, 2020. 3. Hart, Peter E., David G. Stork, and Richard O. Duda. Pattern classification. Hoboken: Wiley, 2000. 4. Flach, Peter. Machine learning: the art and science of algorithms that make sense of data. Cambridge University Press, 2012. 5. Bishop, Christopher M. "Pattern recognition and machine learning: springer New York." (2006). 6. Goodfellow, Ian, YoshuaBengio, and Aaron Courville. Deep learning. MIT press, 2016. 7. Mitchell, Tom, and Machine Learning McGraw-Hill. "Edition." (1997). 8. machine learning and AI online google course by cassiekozyrkov	
Course Outcomes	1. develop an appreciation for what is involved in learning from data. 2. understand a wide variety of learning algorithms. 3. understand how to apply a variety of learning algorithms to data. 4. understand how to perform evaluation of learning algorithms and model selection. 5. Equips them with a general understanding of deep learning.	

Name of the Programme: MSc Integrated
Course Code: IMC- 402
Title of the Course: Data Modeling and Visualization
Number of Credits: 6(4L-0T-2P)
Effective from AY: 2021-22

Prerequisites for the course:	A basic understanding of data management concepts and knowledge of relationship database tables	
Objective:	1. Learn to understand practical techniques to analyze and model data as part of the overall data management lifecycle 2. To expose students to visual representation methods and techniques that increases the understanding of complex data. 3. Learn to design good design practices for visualization, tools for visualization of data from a variety of fields and visualization software like Processing, GapMinder and Tableau.	
Content Theory:	**Data modeling fundamentals:** The purpose and role of data modelling- basic data modeling concepts and terminology, data modeling building blocks- hierarchies for the entities, data model Constraints for your attributes: specify cross-entity dependencies through strong and weak entities -summary of real-world entity and attributes complexities. real-world complexities to relationships why relationship cardinality and complexities matter - build real-world complexities into data model relationships-define the maximum cardinality of a relationship -define the minimum cardinality of relationship -use crow's foot notation for minimum and maximum cardinality -summary of cardinality and complex relationships. move across the different levels of data model: Harmonize different levels of data model - brief look a relational database normalization -forward-engineering your conceptual data model - more data model forward engineering - reverse engineer a physical model back into conceptual model - summary - how to work with different levels of data model	19 hours
	Software for data modeling: The importance of data modeling software -build a data model with a drawing program - build model with data modeling software tool	9 hours
	Visualization: Right graph for right data, Components of a Data Visualization-Different Types of Graphs, Deadly Sins of Graph Design, How to Avoid Being Mislead with Graphs Session. The Value of Visualization Sessions - Effective Use of Form and Space. Fundamentals of Graphs - Integrity in Visualization-Visual Perception and Quantitative Communication Reading - Effective Use of Form and Space	13 hours
	Detailed Design of Tables and Graphs Readings: Summary at a Glance: Table Design Summary at a Glance: Graph Design Session. Additional Constructs and Multivariate Analysis- Escaping 2 Dimensions: Animated Scatter-Plots-Introduction to Information Design.	7 hours
Content Practical:	• **Data Modelling part - lab hrs – 24 hrs** Suggested Data Modelling and visualization lab assignments These assignments focus on different aspects of data modeling, allowing students to understand and practice conceptual, logical,	

	physical, dimensional, and NoSQL data modelling techniques. They provide hands-on experience in translating real-world scenarios into structured data models. **Assignment 1 - Conceptual Data Modeling:** • Task: Choose a real-world scenario (e.g., online marketplace, banking system) and create a conceptual data model. • Requirements: Identify the main entities, attributes, and relationships in the scenario. Use an appropriate notation (e.g., Entity-Relationship Diagram) to represent the conceptual model. • Deliverables: Conceptual data model diagram, along with a description of the entities, attributes, and relationships. **Assignment -2 -Logical Data Modeling:** • Task: Take the conceptual data model created in the previous assignment and transform it into a logical data model. • Requirements: Specify the tables, columns, primary keys, foreign keys, and relationships based on the conceptual model. Normalize the logical data model to eliminate redundancy. • Deliverables: Logical data model diagram, including table structures, primary and foreign keys, and a brief explanation of the normalization process. **Assignment -3 -Physical Data Modeling:** • Task: Convert the logical data model into a physical data model suitable for implementation in a specific database management system. • Requirements: Choose a database management system (e.g., MySQL, PostgreSQL) and map the logical data model elements to the corresponding database objects (e.g., tables, columns, data types, constraints). • Deliverables: Physical data model diagram, including the database objects, data types, and constraints. **Assignment -4 -Dimensional Modeling for Data Warehousing:** • Task: Design a dimensional model for a data warehousing scenario. • Requirements: Identify the fact tables, dimension tables, and their attributes.Establish relationships and define hierarchies between dimensions. Consider the design principles of star schema or snowflake schema. • Deliverables: Dimensional model diagram (e.g., star schema or snowflake schema), including fact tables, dimension tables, and their attributes. **or** **Assignment – 5 -NoSQL Data Modeling:** • Task: Choose a NoSQL database (e.g., MongoDB, Cassandra) and design a data model for a specific use case. • Requirements: Identify the entities, attributes, and relationships in the use case. Determine the document structure, collections, and indexing strategies based on the NoSQL database's features and query requirements. • Deliverables: Data model representation (e.g., JSON-like documents, key-value pairs) and a brief explanation of the design choices made.	5 hours 5 hours 5 hours 5 hours 4 hours

	• **Visualization part - lab hrs -24 hrs** These assignments focus on different aspects of data visualization, allowing students to practice creating various types of visualizations and effectively communicating insights. They provide hands-on experience in data exploration, interactive dashboard design, geospatial analysis, network visualization, and storytelling with data. **Assignment -1 Exploratory Data Visualization:** • Task: Choose a dataset of your choice and create a set of visualizations to explore and understand the data. • Requirements: Use a visualization library (e.g., Matplotlib, Seaborn, Plotly) to create a variety of charts and plots, such as scatter plots, line charts, bar charts, and heatmaps. Highlight important patterns, trends, and relationships in the data. • Deliverables: Jupyter notebook or script with code, along with a report explaining the insights gained from the visualizations. **Assignment -2 Interactive Dashboard Design:** • Task: Design an interactive dashboard for a specific business scenario or data analysis task. • Requirements: Use a dashboarding tool like Tableau, Power BI, or Plotly Dash to create a visually appealing and interactive dashboard. Include multiple visualizations, filters, and interactive elements to allow users to explore and analyze the data. • Deliverables: Interactive dashboard, documentation explaining the design choices, and a user guide. **Assignment -3 -Geospatial Data Visualization:** • Task: Visualize geospatial data on maps to uncover insights and patterns. • Requirements: Utilize libraries like Folium, Plotly, or D3.js to create maps and plot geospatial data. Represent data using markers, choropleth maps, heatmaps, or other appropriate visualizations. Explore relationships between the data and geographic locations. • Deliverables: Interactive map visualizations, code snippets, and a report summarizing the findings. **Assignement -4 Network Visualization:** • Task: Visualize relationships and networks within a dataset. • Requirements: Use network visualization libraries like NetworkX, Gephi, or Cytoscape.js to create visual representations of nodes and edges. Explore connectivity, centrality, and other network metrics to analyze and understand the underlying structure. • Deliverables: Network visualization diagrams, code snippets, and a report explaining the insights gained from the visualizations. **Assignment – 5 Storytelling with Data:** • Task: Create a data-driven story using visualizations to convey a narrative or message. • Requirements: Choose a topic or dataset and design a series of visualizations that support your story. Use appropriate charts, images, and annotations to guide the audience through the narrative. Ensure a logical flow and effectively communicate the intended message.	5 hours 5 hours 5 hours 5 hours 4 hours

	• Deliverables: A presentation or report with a coherent narrative, visualizations, and accompanying explanations.	
Pedagogy:	lab assignments/ theory assignments /mini case study/capstone project	
References/ Readings	1. Hoberman, Steve. Data modeling made simple: a practical guide for business and IT professionals. Technics Publications, 2015. 2. Edward Tufte, The Visual Display of Quantitative Information 3. Tufte, Edward R., Nora Hillman Goeler, and Richard Benson. Envisioning information. Vol. 2. Cheshire, CT: Graphics press, 1990. 4. Fry, Ben. Visualizing data: Exploring and explaining data with the processing environment. " O'Reilly Media, Inc.", 2008. **Data Modeling:** 1. "Database Systems: The Complete Book" by Hector Garcia-Molina, Jeffrey D. Ullman, and Jennifer Widom 2. "The Data Model Resource Book: A Library of Universal Data Models for All Enterprises" by Len Silverston 3. "Data Modeling Essentials" by Graeme Simsion and Graham Witt **Data Visualization:** 1. "The Visual Display of Quantitative Information" by Edward R. Tufte 2. "Data Visualization: A Practical Introduction" by Kieran Healy 3. "Storytelling with Data: A Data Visualization Guide for Business Professionals" by Cole Nussbaumer Knaflic 4. "Information Visualization: Perception for Design" by Colin Ware	
Course Outcomes	1. Understand data modeling principles and create effective data models. 2. Design databases based on data models and optimize database structures. 3. Use data visualization tools and software to create informative visualizations. 4. Communicate insights and findings through visually appealing data visualizations.	

Name of the Programme: MSc Integrated
Course Code: IMC- 403
Title of the Course: Linear Programming & Optimization
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2021-22

Prerequisites for the course:	Linear Algebra	
Objective:	To provide students the theoretical knowledge to effectively formulate linear programming problem and optimization.	
Content:	**Introduction to Operational Research (OR):** Origin & Development, Different Phases of OR study, Methodology of OR, Scope and Limitations of OR, Applications of OR.	4 hours
	Linear Programming: Linearly independent / dependent vectors, Basis, Convex sets, Extreme points. Graphical method.	10 hours
	Simplex method and its variant: Simplex method, Artificial variable techniques- Two Phase Method; M-Charnes Method, Special cases in LPP.	12 hours
	Duality: Definition of the dual problem, Primal-dual relationships, Economic Interpretation of Duality, Dual simplex Method.	12 hours
	Sensitivity analysis: Changes in cost and resource vector	4 hours
	Special Cases of Optimization Problems: Assignment Problems, Transportation Problem	6 hours
Pedagogy:	Lectures/ tutorials/assignments/class presentations and debates/peer reviews / workshops/self-study	
References/ Readings	1. G. Hadley: Linear Programming. Narosa, 2002 (reprint). 2. A. Ravindran, D. T. Phillips and James J. Solberg: Operations Research-Principles and Practice, John Wiley & Sons, 2005. 3. Hamdy A. Taha: Operations Research-An Introduction, Prentice Hall, 8th Edition, 2008. 4. F.S. Hillier. G.J. Lieberman: Introduction to Operations Research- Concepts and Cases, 9th Edition, Tata McGraw Hill. 2010.	
Course Outcomes	1. Understand and apply the principles of linear programming for optimization problems. 2. Solve linear programming problems using graphical and algebraic methods. 3. Utilize optimization software tools to model and solve linear programming problems. 4. Analyze sensitivity and duality in linear programming.	

Name of the Programme: MSc Integrated
Course Code: IMC- 404
Title of the Course: Econometrics I
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2021-22

Prerequisites for the Course:	Understanding of probability and statistics	
Objective:	Equip the students to make sense of empirical data using multiple variables and analytical approaches	
Content:	**Module 1:** The Nature of Econometrics and Economic; Regression Analysis with Cross-Sectional Data; The Simple Regression Model	12 hours
	Module 2: Multiple Regression Analysis: Estimation and Inference; OLS Asymptotics	12 hours
	Module 3: Multiple Regression Analysis with Qualitative Information: Binary (or Dummy) Variables; Heteroskedasticity; Other Specification and Data Issues	12 hours
	Module 4: Regression Analysis with Time Series: Basic Regression Analysis with Time Series Data; Serial Correlation and Heteroskedasticity in Time Series Regressions	12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
Reference/ Readings:	Essential Reading Wooldridge, J. (2018). *Introductory econometrics: A modern approach* (7th edition). Cengage Learning. Additional Reading Angrist, J. D., &Pischke, J.-S. (2009). *Mostly harmless econometrics: An empiricist's companion*. Princeton University Press. Heiss, F. (2020). *Using R for introductory econometrics*.https://elopage.com/s/florian-heiss/using-r-for-introductory-econometrics	
Course Outcomes:	1. Understand and apply econometric principles and techniques. 2. Analyze economic data and estimate relationships between variables. 3. Use statistical software for econometric analysis. 4. Interpret and evaluate econometric results.	

Name of the Programme: MSc Integrated
Course Code: IMC- 405
Title of the Course: Soft Skills IV (Public Speaking Skills)
Number of Credits: 2(2L-0T-0P)
Effective from AY: 2021-22

Prerequisites for the course:	Nil	
Objective:	To provide students with an ability to address larger audien!1+1ces confidently.	
Content:	**Preparation for delivering a speech: S**election of topic, Relevant data collection, Draft preparation etc. **Listening to famous speeches.:** The faculty will choose some famous public speeches and make them listen to the students. The students then will have to analyse them. **Making speeches:** The students will be asked to make public speeches by implementing the learning.	8 hours 8 hours 8 hours
Pedagogy:	Lectures/ tutorials/assignments/class presentations/Role plays and debates/peer reviews/workshops/self-study	
References/ Readings	1. Dale Carnegie with J. Berg Eisenwen: The art of public speaking, Rupa publications India Pvt. Ltd., Latest edition. 2. Topher Morrison: The Book on Public Speaking, MJ Publishers, Latest Edition.. 3. Chris Anderson et.al: HBR's 10 Must Reads on Public Speaking and Presenting, HBR, Latest Edition	
Course Outcomes	1. Develop confidence in public speaking. 2. Improve verbal and nonverbal communication skills. 3. Structure and organize speeches effectively. 4. Use visual aids to support presentations.	

Name of the Programme: MSc Integrated
Course Code: IMC- 406
Title of the Course: Perspective Building Course - III (Music Appreciation)
Number of Credits: 2(2L-0T-0P)
Effective from AY: 2021-22

Prerequisites the forcourse:	Nil	
Objective:	To make the participants appreciate different genres of music.	
Content:	• What is Sound/Music?, Facets of Music, Art of listening to Music. • How Music works, Elements of Music. • Fundamentals of Music. Rhythm, Melody, Harmony, Timbre. • Music instruments genres- Strings, Wood wind, Percussion, Brass EDM. • Different Musical Eras, History of Music, Genres of Music. • Appreciating forms, styles and genres of Classical Music: Film music, fusion music	4 hours 4 hours 4 hours 4 hours 4 hours 4 hours
Pedagogy:	Lectures/ tutorials/laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Course Outcomes :	1. Gain understanding and appreciation of diverse music genres. 2. Identify and analyze musical elements and structures. 3. Explore historical and cultural contexts of music. 4. Recognize notable composers and musicians.	
References/ Readings:	1. Music Videos from Dave Conservatoire. 2. Music Videos from Stephen Titra. 3. Baugh's Music Theory videos from YouTube. 4. The Young Person's Guide to the Orchestra. Harcourt Childrens Books, 1996 or later edition 5. How Music Works series by Howard Goodall, Channel 4 Network; 2010 or latest edition	

Name of the Programme: MSc Integrated
Course Code: IMC- 501
Title of the Course: Computer Organization & Operating Systems
Number of Credits: 6(4L-0T-2P)
Contact Hours: 96hours (48L-0T-48P)
Effective from AY: 2022-23

Prerequisites for the course:	Nil	
Objective:	The aim of the course is to provide students the theoretical and conceptual knowledge of Computer System Architecture and Operating systems.	
Content Theory:	**Introduction to digital electronics:** Logic gates, boolean algebra, combinational circuits	2 hours
	Data Representation and Basic Computer Arithmetic: Number systems, complements, fixed and floating point representation, character representation, addition, subtraction	2 hours
	Basic Computer Organization and Design: Computer registers, instruction set, instruction cycle, input-output and interrupt, Bus Interconnection design of basic computer.	4 hours
	Central Processing Unit: Register organization, arithmetic and logical micro-operations, stack organization, micro programmed control. Instruction formats, addressing modes.	4 hours
	Memory and Input-Output Organization: Cache memory, Associative memory, and mapping, Input / Output: External Devices, I/O Modules, Programmed I/O, Interrupt-Driven I/O, Direct Memory Access.	3 hours
	Introduction to Operating Systems Basic OS functions, resource abstraction, types of operating systems.	3 hours
	Operating System Organization: Processor and user modes, kernels, system calls and system programs.	4 hours
	Process Management: System view of the process and resources, process abstraction, process hierarchy, threads, threading issues, thread libraries; Process Scheduling, non-pre-emptive and preemptive scheduling algorithms; Concurrent processes, critical section, semaphores, methods for inter-process communication; deadlocks.	12 hours
	Memory Management: Physical and virtual address space; memory allocation strategies -fixed and variable partitions, paging, segmentation, virtual memory	6 hours
	File and I/O Management: Directory structure, file operations, files allocation methods, device management.	5 hours
	Protection and Security: Policy mechanism, Authentication, Internal access Authorization.	3 hours
Content Practical:	**Suggested Lab Assignments with each assignment with duration of 4 hrs** 1. Sample assignment for introduction to the environment of the UNIX program. 2. Sample assignment for introduction to vi editor. 3. Assignment for use of paths: absolute, relative and search. 4. Assignment for use of unix file commands. 5. Assignment for use of unix directory commands. 6. Assignment for use of simple filters: who, sorts, tail, head, etc.	12 * 4 = 48 hours

	7. Introduction to Command substitution : foreground and background processors. 8. Assignment for use of process management commands. 9. Assignment for sse of redirection commands. 10. Assignment for use of wildcards and regular expressions. 11. Assignment for use of complex commands: pipelining commands. 12. Assignment for use of advanced filters: grep, sed, tr and awk.	
Pedagogy:	Lectures/tutorials/assignments/class presentations and debates/peer reviews / workshops /self-study	
References/ Readings	1. M. Mano, Computer System Architecture, Pearson Education 1992 2. W. Stallings, Computer Organization and Architecture Designing for Performance, 8th Edition, Prentice Hall of India,2009 3. M.M. Mano , Digital Design, Pearson Education Asia,2013 4. A Silberschatz, P.B. Galvin, G. Gagne, Operating Systems Concepts, 8th Edition, John Wiley Publications 2008. 5. A.S. Tanenbaum, Modern Operating Systems, 3rd Edition, Pearson Education 2007. 6. G. Nutt, Operating Systems: A Modern Perspective, 2nd Edition Pearson Education 1997. 7. W. Stallings, Operating Systems, Internals & Design Principles, 5th Edition, Prentice Hall of India. 2008. 8. M. Milenkovic, Operating Systems- Concepts and design, Tata McGraw Hill 1992.	
Course Outcomes	1. Understand computer organization and architecture, including data representation, computer arithmetic, CPU organization, memory, and I/O. 2. Explore operating system design and services, including process synchronization and scheduling, memory management, and file system organization. 3. Learn about the structure and organization of the file system, including system calls for managing processes, memory, and file operations. 4. Gain knowledge of system-level components, such as CPU, registers, memory, I/O, and their integration within an operating system for efficient and reliable computing.	

Name of the Programme: MSc Integrated
Course Code: IMC- 502
Title of the Course: Programming in C++
Number of Credits: 6(4L-0T-2P)
Effective from AY: 2022-23

Prerequisites for the course:	Nil	
Objective:	**The subject aims to provide the student with:** 1. An understanding of the concept of object oriented programming. 2. An understanding of the concepts of data hiding, data abstraction, polymorphism inheritance and exception handling. 3. Ability to understand the generic principles of object oriented programming using "C++". 4. An understanding of the use of templates in "C++". 5. An ability to plan, design, execute and document sophisticated object oriented programs to handle different computing problems.	
Content Theory:	Programming paradigm; procedural to object oriented, Basic concepts of Object-Oriented Programming: Objects, Classes, Data Abstraction and Encapsulation, Inheritance, Polymorphism, Dynamic Binding, Message Passing. Benefits of Object-Oriented Programming. Structure of a C++ program, Data types, Constants, tokens, expressions, control structures, functions, recursion, arrays.	12 hours
	Classes and Objects, Constructors and destructors, Friend functions and friend classes, Concepts of polymorphism: Function overloading, operator overloading. Overloading types, & rules, explicit & implicit type conversion operators, Pointers.	12 hours
	Inheritance: Introduction, Single, Multilevel, Multiple, Hierarchical, Hybrid. Virtual Base Class, Abstract classes. 'this' pointer, pointers to deriver classes Virtual functions, pure virtual functions. I/O streams and classes, managing output with Manipulators, Classes for file streams, file I/O operations and functions. String processing.	12 hours
	Functions Templates and Class Templates, Exception handling: Basics of Exception Handling, Exception Handling mechanism, Throwing Mechanism, Throwing Mechanism, Catching mechanism, Re-throwing mechanism. Introduction to the Standard Template Library: Components of STL, Containers and Adapter: stack, queue, priority queue adapter algorithms, Iterators, Applications.	12 hours
Content Practical:	**Suggested Lab Assignments - with minimum duration of 4 hrs for each assignment.** 1. Assignment on Basics of C++ (input /output / control statements / array). 2. Assignment on Classes and objects. 3. Assignment on Function Overloading. 4. Assignment on Operator Overloading. 5. Assignment on Constructors and Destructors. 6. Assignment on Inheritance and Polymorphism. 7. Assignment on Console I/O and Files. 8. Assignment on Templates. 9. Assignment on Exception Handling. 10. Assignment on Standard Template Library. 11. Mini project using OOP paradigm (minimum 8 hours)	10 * 4 = 40 hours(for assignments) + 8 hours (for mini project) = 48 hours

Pedagogy:	Lectures/tutorials/practical assignments/self-study
References/Readings	1. C++ : from control structures through objects / Tony Gaddis. 2. Timothy Budd, —An Introduction to Object Oriented Programming, Pearson Education, 3rd Edition 3. Paul Deitel and HarreyDietel; C++, How to Program; seventh edition. 4. E Balaguruswamy; Object oriented programming with C++; Tata McGraw Hill.6th edition.
Course Outcomes	1. The various programming constructs in C++ and their usage 2. To write modular and readable code using C++ 3. To trace the execution of code fragments. 4. Learner will appreciate mapping real-world scenarios in the object-oriented world, understand object-oriented principles and design object oriented software

Name of the Programme: MSc Integrated
Course Code: IMC- 503
Title of the Course: Data Science Toolkit
Number of Credits: 4(2L-0T-2P)
Effective from AY: 2022-23

Prerequisites for the course:	Knowledge of data science and data analytics	
Objective:	The aim of this course is to provide an introduction to the main tools and ideas in the data scientist's toolbox.	
Content Theory::	**Excel for Data Visualization**: Predefined, custom number and conditional data format for cells; macros; sorting and filtering data; plotting charts and graphs; working across sheets in excel file; creating interactive dashboards, Pivot table, lookup functions **Numeric and Statistical Computing:** Programming and functions; strings, lists, arrays, matrices and data frames; R packages; working with data (e.g. csv, excel, xml, json); plot graphs and charts; R statistical functions and models **Markdown**: Document structure; basic text formatting; paragraphs; headings; lists; links and images; code blocks; escape characters; HTML elements; converting markdown to html web pages **Source Version Control:** Version Control; introduction to SVN and Git; Git repositories; Git cloning, forks and branches; Git stash; Git pull requests; resolving Git merge conflicts; maintaining your Git pages	6 hours 6 hours 6 hours 6 hours
Content Practical:	**Suggested Lab Assignments** (1) Sample Assignments using Excel (a) Using a provided sample dataset excel file (containing office supplies dats, or food sales), format the columns for different currency (currency unit and thousands' delimiter) based on geo location mentioned (2) Sample Assignments using R (3) Sample Assignments using Markdown (4) Sample Assignments using Git	4 * 12 = 48 hours
Pedagogy:	Lectures/tutorials/practical assignments/self-study	
References/Readings	1. Alexander, Kusleika, Walkenbach, "Excel Bible", Wiley 2. Wickham, Grolemund, "R for Data Science", O'Reilly 3. Matt Cone, "The Markdown Guide" 4. Chacon, Straub, "Pro Git", Apress	
Course Outcomes	1. Create a Github repository 2. Explain essential study design concepts 3. Set up R, R-Studio, Github and other useful tools 4. Understand the data, problems, and tools that data analysts work with.	

Name of the Programme: MSc Integrated
Course Code: IMC- 504
Title of the Course: Strategic Management
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2021-22

Prerequisites for the course:	Nil	
Objective:	To create an awareness of knowledge and tools used for industry and firm analysis in designing organizational strategies and their implementation	
Content:	**Introduction to Strategy** Strategy meaning & importance, Strategy development process, Vision, Mission statements, Objectives of the company. **External and Internal Analysis of Firms** Evaluating company's external environment (Porter's 5 Forces Analysis, Political Economic Social Technological Environmental Legal (PESTEL) Analysis), Evaluating company's internal environment (Strength Weakness Opportunity Threats (SWOT) Analysis), resource capabilities, & competitive environment **Crafting Strategy** Five generic competitive strategies: Low cost, Broad Differentiation, Focussed Differentiation, Focussed Low Cost, Best Cost Strategy.	8 hours 20 hours 20 hours
Pedagogy:	Lectures/ tutorials/laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Course Outcomes	1. Understand strategic management concepts and frameworks. 2. Analyze external and internal business environments. 3. Formulate and implement effective business strategies. 4. Foster innovation, adapt to change, and consider ethical and social responsibility.	
References/ Readings	1. Arthur Thompson Jr., Margaret Petarf, John Gamble, Strickland III &Arun K. Jain, "Crafting and Executing Strategy", MacGraw Hill Publication, Latest Edition. 2. Bowman, Cliff: 'The Essence of Strategic Management'; Prentice Hall of India Private Ltd; New Delhi; Latest Edition. 3. Faulkner, David and Cliff Bowman; 'The Essence of Competitive Strategy'; Prentice Hall of India Private Ltd; New Delhi; Latest Edition. 4. Industry notes and business stories from popular business periodicals, databases.	

Name of the Programme: MSc Integrated
Course Code: IMC- 505
Title of the Course: Econometrics II
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2021-22

Prerequisites for the Course:	Understanding of probability and statistics and basic Econometrics 1 or equivalent.	
Objective:	Equip the students to make sense of empirical data using multiple variables and analytical approaches	
Content:	**Module 1:** Pooling Cross Sections Across Time: Simple Panel Data Methods; Advanced Panel Data Methods **Module 2:** Instrumental Variables Estimation and Two Stage Least Squares; Simultaneous Equations Models **Module 3:** Limited Dependent Variable Models and Sample Selection Corrections; Logit and Probit Models for Binary Response; Tobit censored models **Module 4:** Advanced Time Series: Distributed Lag Models; Testing for Unit Roots; Spurious Regression; Cointegration; Error Correction Models; Forecasting	12 hours 12 hours 12 hours 12 hours
Pedagogy:	Lectures/ tutorials/assignments/self-study	
Reference/Readings:	1. Wooldridge, J. (2018). *Introductory econometrics: A modern approach* (7th edition). Cengage Learning. 2. Angrist, J. D., &Pischke, J.-S. (2009). *Mostly harmless econometrics: An empiricist's companion*. Princeton University Press. 3. Heiss, F. (2020). *Using R for introductory econometrics*.https://elopage.com/s/florian-heiss/using-r-for-introductory-econometrics	
Course Outcomes:	1. Apply advanced econometric techniques to analyze complex economic data. 2. Conduct independent econometric research projects. 3. Evaluate and critique existing econometric studies. 4. Explore advanced topics in econometrics, such as panel data analysis and limited dependent variable models.	

Name of the Programme: MSc Integrated
Course Code: IMC- 506
Title of the Course: Perspective Building Course - IV (Leadership)
Number of Credits: 2(2L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course:	Nil	
Objective	To introduce the concepts of leadership and developing leaders at work-place.	
Contents	**Unit I** **Introduction to Leadership** Leadership and Person, Personality, cultural values and ability, Leadership that gets results, Emotional Intelligence, Models of Leadership, Leadership theories: Traits, Situational, and Functional leadership, Leadership and Power, Leadership and Influence: Interpersonal Conflict and Negotiation, Leadership in Groups and Teams	6 hours
	Unit II **Leadership and Organisation** Organizations as Complex Systems: Strategy, Structure & Environment, Organizational Culture, Leading Teams: Design and Structure, Leadership and Communication, Leading Change	6 hours
	Unit III **Leadership Development** Identifying potential leaders, Leader Development Vs Leadership Development, Process of leadership Development, Developmental Readiness of employees, Tools and interventions for developing leadership	6 hours
	Unit IV **Special Leadership dimensions** Identifying potential dark/ Negative leadership, Corrective measures, Public Leadership, Academic Leadership, Spiritual Leadership, Transformational leadership, Leadership in different types of organisations: Small businesses, Family Businesses, Global Organisations	6 hours
Pedagogy	lectures/ tutorials/laboratory work/ field work/ outreach activities/ project work/ vocational training/viva/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Course Outcomes	1. Develop leadership skills: Enhance abilities in communication, decision-making, problem-solving, and team building. 2. Understand leadership theories: Explore different leadership styles and models to gain a theoretical foundation for effective leadership practices. 3. Foster ethical leadership: Cultivate ethical behavior, integrity, and accountability in leadership roles. 4. Enhance teamwork and collaboration: Develop skills in collaboration, conflict resolution, and motivating others to achieve common goals within diverse teams.	
References/ Readings.	1. RL Hughes, RC Ginnett, GJ Curphy; Leadership; Tata McGraw Hill; 2022 or latest edition. 2. James Kouzes, Barry Posner, Jossey-Bass; The Leadership Challenge; 2002 or Latest edition. 3. J Owen, Kogan; The Leadership Skills Handbook; Page Publishing; 2020 or latest	

	edition. 4. WG Rowe, L Guerrero; Cases in Leadership; Sage Publications; 2015 or latest edition. 5. JH Zenger, JR Folkman; The Extraordinary Leader; Tata McGraw Hill; 2002 or latest edition.

Name of the Programme: MSc Integrated
Course Code: IMC - 601
Title of the Course: Introduction to Data Science
Number of Credits: 6(4L-0T-2P)
Effective from AY: 2022-23

Prerequisites for the course	Statistics and Probability theory and Python Programming	
Objectives	To get started with basics of Data Science and learn all aspects of Data Science in its entirety	
Content Theory:	**Unit-1: Basics of Data Science:** Introduction; Typology of problems-**Data science in a big data world:** Benefits and uses of data science and big data-Facets of data-The data science process-The big data ecosystem and data science-**The data science process:** Overview of the data science process- Defining research goals and creating a project charter-Retrieving data-Cleansing, integrating, and transforming data-Exploratory data analysis-Build the models- Presenting findings and building applications on top of them.	6 hours
	Unit -2: Mathematics for Data science (Revision): • Importance of linear algebra, statistics and optimization from a data science perspective; Structured thinking for solving data science problems. • Linear Algebra: Matrices and their properties (determinants, traces, rank, nullity, etc.); Eigenvalues and eigenvectors; Matrix factorizations; Inner products; Distance measures; Projections; Notion of hyperplanes; half-planes. • Probability, Statistics and Random Processes: Probability theory and axioms; Random variables; Probability distributions and density functions (univariate and multivariate); Expectations and moments; Covariance and correlation; Statistics and sampling distributions; Hypothesis testing of means, proportions, variances and correlations; Confidence (statistical) intervals; Correlation functions; White-noise process.	7 hours
	Unit -3: Introduction to Data Science Methods: Linear regression as an exemplar function approximation problem; Linear classification problems.	7 hours
	Unit -4: Handling large data on a single computer: • The problems you face when handling large data-General techniques for handling large volumes of data-General programming tips for dealing with large data sets-Case study 1: Predicting malicious URLs-**First steps in big data-**Distributing data storage and processing with frameworks	7 hours
	Unit 5: Join the NoSQL movement-Introduction to NoSQL	7 hours
	Unit 6: The rise of graph databases: • Introducing connected data and graph databases • Introducing Neo4j: a graph database	7 hours
	Unit 7: Data visualization to the end user: • Data visualization options • Crossfilter, the JavaScript MapReduce library • Creating an interactive dashboard with dc.js • Dashboard development tools	7 hours

Content Practical:	**Suggested Lab Assignment:** **Program to understand these concepts**: Numpy Arrays objects, Creating Arrays, basic operations, Indexing, Slicing and iterating, copying arrays, shape manipulation, Identity array, eye function, Universal function **Program to understand these concepts:** Linear algebra with Numpy, eigen values and eigen vectors with Numpy **Program to understand these concepts:** Aggregation and Joining, Pandas Object: Concatenating and appending data frames, index objectsHandling Time series data using pandas **Program to understand these concepts:** Handling missing values using pandas **Program to understand these concepts:** Reading and writing the data including JSON data **Program to understand these concepts:** Web scraping using python, Combining and merging **Program to understand these concepts:** Data transformations Basic matplotlib plots, common plots used in statistical analysis in python **Program to understand these concepts:** Common plots used in statistical analysis in python Data Types **Program to understand these concepts:** Sequence generation, Vector and subscript, Random number generation Data frames and functions-Data manipulation and Data Reshaping using plyr, dplyr, reshape **Program to understand these concepts:** Parametric statistics and Non-parametric statistics- Continuous and Discrete Probability distribution using python Correlation and covariance, contingency tables- Overview of Sampling, different sampling techniques- and database connectivity2.	15 hours 5 hours 5 hours 5 hours 5 hours 5 hours 4 hours 4 hours
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	1. Practical Statistics for Data Science by Peter Bruce, Andrew Bruce, Peter Gedeck, May 2017 2. Naked Statistics by Charles Wheelon, 2012 3. Business Data Science by Matt Taddy, McGraw Hill, 2019 4. Elements of statistical learning by Jerome H. Friedman, Robert Tibshirani, and Trevor Hastie,2001 5. Python for Data Analysis by Wes McKinney, 2nd edition, 2017 6. Data Science and Big Data Analytics -EMC2 7. James Payne, “Beginning Python: Using Python 2.6 and Python 3.1” Wrox, Ist Edition, 2010. 8. Michael T. Goodrich, Roberto Tamassia, Michael H. Goldwasser, “Data Structures and Algorithms in Python”, John Wiley & sons, 2013. 9. Ivan Idris, “Python Data Analysis”, Packt Publishing Limited, 2014. 10. Wes McKinney, “Python for Data Analysis Data Wrangling with Pandas, NumPy, and IPython”, O'Reilly Media, Ist Edition, 2012. 11. Michael Heydt, “Learning Pandas - Python Data Discovery and Analysis Made Easy”, Packt Publishing Limited, 2015. 12. Jacqueline Kazil,KatharineJarmul, “Data Wrangling with Python: Tips and Tools to MakeYour Life Easier”, O'Reilly Media, Ist Edition, 2016.	

	13. https://docs.scipy.org/doc/numpy-dev/reference/index.html#reference 14. http://www.python-course.eu/numpy.php
Course Outcomes	1. Understand key data science concepts. 2. Learn programming skills for data manipulation and analysis. 3. Apply data analysis techniques, including preprocessing and basic modeling. 4. Communicate data insights effectively through visualizations and presentations

Name of the Programme: MSc Integrated
Course Code: IMC- 602
Title of the Course: Big Data Frameworks
Number of Credits: 6(4L-0T-2P)
Effective from AY: 2022-23

Prerequisites for the course	Probability and Statistics; Python Programming	
Objectives	• To understand the need of Big Data, challenges and different analytical architectures • Installation and understanding of Hadoop Architecture and its ecosystems • Processing of Big Data with Advanced architectures like Spark. • Describe graphs and streaming data in Spark	
Content Theory:	**Introduction to Big Data:** Data Storage and Analysis - Characteristics of Big Data – Big Data Analytics - Typical Analytical Architecture – Requirement for new analytical architecture – Challenges in Big Data Analytics – Need of big data frameworks	9 hours
	Hadoop framework: Hadoop – Requirement of Hadoop Framework - Design principle of Hadoop –Comparison with other system - Hadoop Components – Hadoop 1 vs Hadoop 2 – Hadoop Daemon's – HDFS Commands – Map Reduce Programming: I/O formats, Map side join, Reduce Side Join, Secondary sorting, Pipelining MapReduce jobs -	7 hours
	Hadoop Ecosystem : Introduction to Hadoop ecosystem technologies: Serialization: AVRO, Co-ordination: Zookeeper, Databases: HBase, Hive, Scripting language: Pig, Streaming: Flink, Storm	7 hours
	Spark framework: Introduction to GPU Computing, CUDA Programming Model, CUDA API, Simple Matrix, Multiplication in CUDA, CUDA Memory Model, Shared Memory Matrix Multiplication, Additional CUDA API Features.	7 hours
	Data analysis with spark shell: Writing Spark Application - Spark Programming in Scala, Python, R, Java - Application Execution	6 hours
	Spark SQL and Graph X : SQL Context – Importing and Saving data – Data frames – using SQL – GraphX overview – Creating Graph – Graph Algorithms.	6 hours
	Spark Streaming: Overview – Errors and Recovery – Streaming Source – Streaming live data with spark	6 hours
Content Practical:	**Suggested Lab Assignments:** 1. Downloading and installing Hadoop; Understanding different Hadoop modes. Startup scripts, Configuration files. 2. Hadoop Implementation of file management tasks, such as Adding files and directories, Retrieving files and Deleting files 3. Implement of Matrix Multiplication with Hadoop Map Reduce 4. Run a basic Word Count Map Reduce program to understand Map Reduce Paradigm. 5. Implementation of K-means clustering using Map Reduce 6. Installation of Hive along with practice examples. 7. Installation of HBase, Installing thrift along with Practice examples 8. Patrice importing and exporting data from various databases .	8 * 6 = 48 hours
Pedagogy	Assignment / Quiz / Project / Seminar	

References/ Readings	1. Mike Frampton, “Mastering Apache Spark”, Packt Publishing, 2015. 2. Tom White, “Hadoop: The Definitive Guide”, O’Reilly, 4thEdition, 2015. 3. Nick Pentreath, Machine Learning with Spark, Packt Publishing, 2015. 4. Mohammed Guller, Big Data Analytics with Spark, Apress, 2015. 5. Donald Miner, Adam Shook, “Map Reduce Design Pattern”, O’Reilly, 2012.
Course Outcomes	1. Understand big data fundamentals. 2. Learn big data technologies (e.g., Hadoop, Spark). 3. Analyze and process large datasets using distributed computing. 4. Apply big data analytics techniques for valuable insights.

Name of the Programme: MSc Integrated
Course Code: IMC- 701
Title of the Course: AI-Search Methods for Problem Solving
Number of Credits: 6(4L-0T-2P)
Effective from AY: 2022-23

Prerequisites for the course	Programming skills, Data structures, Mathematical Foundations	
Objectives	The Objective of this course is to learn the fundamentals of Artificial Intelligence. The focus is on blind search methods - blind search, heuristic search methods etc and appreciate formulating the problem as state space representation.	
Content Theory	Introduction and philosophy. The Turing Test. The Winograd Schema Challenge. Placing search in the landscape of AI. Search spaces. Examples. State space search. Depth First, Breadth First, Iterative Deepening. Analysis. Heuristic search. Heuristic functions. Solution space search. Escaping local optima. Stochastic local search.	12 hours
	Population based methods. Genetic Algorithms, emergent systems, Ant Colony Optimization. Finding optimal paths. Algorithm A*. Admissibility of A*. The monotone condition. Space saving versions of A*. Sequence alignment.	12 hours
	Game playing. Board games. Algorithms Minimax, Alpha-Beta, and SSS*. Automated domain independent planning. Goal Stack Planning, Partial Order Planning. Problem decomposition with goal trees. Algorithm AO*.	12 hours
	Pattern directed inference systems. Forward chaining inference engine. The Rete algorithm.Constraint processing. Algorithm Backtracking. Arc consistency. Combining search and reasoning. Waltz algorithm. Model based diagnosis.	12 hours
Content Practical	Implementation of Toy problems Developing Agent programs for real world problems Implementation of constraints satisfaction problems Implementation and Analysis of DFS and BFS for an application Developing Best First search and A* Algorithm for real world problems Implementation of minimax algorithm for an application Implementation of unification and resolution for real world problems Implementation of knowledge representation schemes-use cases Implementation of uncertain methods for an application Implementation of block world problem Implementation of learning algorithm for an application Development of ensemble model for an application	12 * 4 = 48 hours
Pedagogy	Hands-on Assignments / Tutorials / Peer-teaching / Presentations	
References/ Readings	1. Deepak Khemani. A First Course in Artificial Intelligence, McGraw Hill Education (India), 2013. (Chapters 1 – 8, some parts from Chapters 9 and 10)) 2. John Haugeland, Artificial Intelligence: The Very Idea, A Bradford Book, The MIT Press, 1985. 3. Pamela McCorduck, Machines Who Think: A Personal Inquiry into the History and Prospects of Artificial Intelligence, A K Peters/CRC Press; 2nd edition, 2004. 4. Eugene Charniak and Drew McDermott, Introduction to Artificial Intelligence, Addison- Wesley Publ., 1985.	

	5. ZbigniewMichalewicz and David B. Fogel. How to Solve It: Modern Heuristics. Springer; 2nd edition, 2004. 6. Judea Pearl. Heuristics: Intelligent Search Strategies for Computer Problem Solving, Addison-Wesley, 1984. 7. Elaine Rich and Kevin Knight. Artificial Intelligence, Tata McGraw Hill, 1991. 8. Stuart Russell and Peter Norvig. Artificial Intelligence: A Modern Approach, 3rd Edition, Prentice Hall, 2009. 9. Patrick Henry Winston. Artificial Intelligence, Addison-Wesley, 1992. 10. Stefan Edelkamp and Stefan Schroedl. Heuristic Search: Theory and Applications, Morgan Kaufmann, 2011. 11. Artificial programming in Python (zero to zero)By Perry Xiao, 2022 12. AI and Machine Learning for coders by Lawrence, O'ReillyPublication,2020
Course Outcomes	Students will be able to understand: 1. A historical and philosophical perspective on artificial intelligence. 2. The ability to formulate problems in a general problem solving framework and Knowledge of domain independent search based problem solving algorithms. 3. Knowledge of stochastic, local, and population based search algorithmsThe foundations of problem and decomposition and rule based methods. 4. To implement game playing algorithms and The relation between search methods and other formulations including planning, constraints and logical reasoning.

Name of the Programme: MSc Integrated
Course Code: IMC- 702
Title of the Course: Research Methodology and IP
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Basics of probability and statistics , Programming skills	
Objectives	• Present research methodology and the technique of defining a research problem. • Learn the meaning of interpretation, techniques of interpretation, precautions is to be taken in interpretation for research process, • Application of statistical methods in research • Learn intellectual property rights and its constituents.	
Content	**Unit 1** Introduction to research, Definitions and characteristics of research, Types of Research, Research Process, Problem definition, Objectives of Research, Research Questions, Research design, Quantitative vs. Qualitative Approach, Building and Validating Theoretical Models, Exploratory vs. Confirmatory Research, Experimental vs. Theoretical Research, Importance of reasoning in research. **Unit 2** Problem Formulation, Understanding Modeling & Simulation, Literature Review, Referencing, Information Sources, Information Retrieval, Indexing and abstracting services, Citation indexes, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: Sampling, Observation, Interpretation of Results. **Unit 3** Statistics: Probability & Sampling distribution, Estimation, Measures of central Tendency, Arithmetic mean, Median, Mode, Standard deviation, Co-efficient of variation (Discrete serious and continuous serious), Hypothesis testing & application, Correlation & regression analysis, Orthogonal array, ANOVA, Standard error, Concept of point and interval estimation, Level of significance, Degree of freedom, Analysis of variance, One way and two way classified data, 'F' test. **Unit 4** Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents. Intellectual property rights (IPR) patents copyrights Trademarks Industrial design geographical indication. Ethics of Research Scientific Misconduct Forms of Scientific Misconduct. Plagiarism, Unscientific practices in thesis work, Ethics in science.	12 hours 12 hours 12 hours 12 hours
Pedagogy	Lectures/ Tutorials/Assignments/Self-study	
References/ Readings	1. K. S. Bordens, and B. B.Abbott, , "Research Design and Methods – A Process Approach", 8th Edition, McGraw Hill, 2011. 2. C. R. Kothari, "Research Methodology – Methods and Techniques", 2nd Edition, New Age International Publishers,2014 3. Douglas C. Montgomary&George C. Runger, Applied Statistics &probabilityfor	

	Engineers, 3rd edition, 2007, Wiley. 4. Robert P. Merges, Peter S. Menell, Mark A. Lemley, and "Intellectual Property in the New Technological Age". Aspen Law & Business; 6th edition July 2012. 5. A Beginners Guide to Latex, ChetanShirore, 5 July 2015.
Course Outcomes	1. Design and formulation of research problems. 2. Analyze research related information and statistical methods in research. 3. Carry out research problem individually in a perfect scientific method 4. Understand the filing patent applications processes, Patent search, and various tools of IPR, Copyright, and Trademarks.

Name of the Programme: MSc Integrated
Course Code: IMC- 703
Title of the Course: Deep Learning
Number of Credits: 6(4L-0T-2P)
Effective from AY: 2022-23

Prerequisites for the course	Machine Learning, Programming,Probability and Statistics, Linear Algebra	
Objectives	To study the basics of Neural Networks and their various variants such as the Convolutional Neural Networks and Recurrent Neural Networks, to study the different ways in which they can be used to solve problems in various domains such as Computer Vision, Speech and NLP.	
Content Theory	Moving beyond Linearity-Non-Linear regression-polynomial and spline-polynomial regression, step function, basisfunction, regression splines -piecewise polynomials, constraints and splines, the spline basis representation etc - smoothing splines, Generalized additive models	4 hours
	History of Deep Learning, McCulloch Pitts Neuron, Thresholding Logic, Perception Learning Algorithm and Convergence. Multilayer Perceptions (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent. Feed forward Neural Networks, Representation Power of Feed forward Neural Networks, Back propagation. Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, Adagrad, AdaDelta,RMSProp, Adam,AdaMax,NAdam, learning rate schedulers.	8 hours
	Auto encoders and relation to PCA, Regularization in autoencoders, Denoising autoencoders, Sparse autoencoders, Contractive autoencoders. Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout	12 hours
	Greedy Layer Wise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization. Learning Vectorial Representations Of Words, Convolutional Neural Networks, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet. Visualizing Convolutional Neural Networks, Guided Backpropagation, Deep Dream, Deep Art, Fooling Convolutional Neural Networks.	12 hours
	Recurrent Neural Networks, Backpropagation Through Time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT. Gated Recurrent Units (GRUs), Long Short Term Memory (LSTM) Cells, Solving the vanishing gradient problem with LSTM. Encoder Decoder Models, Attention Mechanism, Attention over images, Hierarchical Attention, Transformers.	12 hours
Content Practical	**Suggested Lab Assignments** 1. Data representation for neural networks . 2. The gears of neural networks -Tensor operations. 3. Engine of neural network – implementation of gradient -based optimization algorithm. 4. Getting started with keras- setting up a deep learning workstation.	12 * 4 = 48 hours

	5. Writing program to classify movie reviews-binary classification example. 6. Classifying newswires -multi classification example 7. Predicting house prices-regression example 8. Program to understand the effect of under fitting and over fitting. 9. Training a Convent on a small dataset. 10. Learning to use predefined convent. 11. Sequencing processing example using recurrent network and LSTM 12. Generative deep learning assignment-Text generations with LSTM	
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	1. Ian Goodfellow and YoshuaBengio and Aaron Courville. Deep Learning. An MIT Press book. 2016. 2. Charu C. Aggarwal. Neural Networks and Deep Learning: A Textbook. Springer. 2019. 3. Deep Learning with Python by Francois Chollet, 2017 4. Deep Learning from scratch by ActhEidman, O'Reilly Publication , 2019. 5. Deep learning with PyTorch by Eli Stevens, Luca Antiga, Thomas,2020.	
Course Outcomes	1. Understand deep learning fundamentals. 2. Develop and train deep learning models. 3. Apply deep learning to real-world problems. 4. Evaluate and optimize deep learning models.	

Name of the Programme: MSc Integrated
Course Code: IMC- 704
Title of the Course: Design Thinking for Data-Driven App Development
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	None	
Objectives	This course helps you learn the basics of Design Thinking in an experiential way. This course aims at an empathy-led data-driven app development approach for data scientists. The learners will launch a fully functioning app in a real app store at the end of the course.	
Content	Introduction to Design Thinking – Course outline and projects, Intro to the Design of Everyday Things, Intro to Design Thinking in software apps, Project management. Empathize phase (Iteration #1)-- Emotional and intellectual map of the user stories from interviews, User story creation and Customer Journey Mapping	12 hours
	Analyze phase (Iteration #1) - Stated needs and unsaid/latent needs, Root cause analysis, Multiple perspectives of customers and manufacturers, Frame conflicts from popular movies. Solve phase (Iteration #1)Structured and unstructured creativity, Dynamics of group thinking, Optimal conditions of creativity, Natural creativity, Concept creation via group activities, Silent brainstorming, inventive principles and concept consolidation	12 hours
	Test phase (Iteration #1)/ Empathize phase (Iteration #2) - Basics of prototyping, Assumptions in creation of new concepts, Features rather than ideas. Basics of Digital Marketing, User Experience Design, Website Development	12 hours
	Analyze phase (Iteration #2) Solve phase (Iteration #2) - Introduced problems via the solution from iteration #1, the subsequent ideation process in iteration #2, apply solutioning and analysis tools in iteration #2, subsequent testing and field trial skills required for iteration #3, analytical tools and data oriented tools on iteration #3. Test (Iteration #2) / Empathize (Iteration #3) - Basics of obtaining insights from feedback from a live audience. Analyze (Iteration #3). Test phase (Iteration #3) - Launch of the App.	12 hours
Pedagogy	Hands-on assignments / Tutorials / Peer-teaching /Presentations	
References/ Readings	1. Design of everyday things by Don A. Norman, 2013. 2. This is Service Design thinking- basics, tools and cases by Marc Stickdorn, 1st edition,John Wiley & Sons Inc,2012.	
Course Outcomes	1. Recall the basics of Design Thinking and Apply Agile method to developing software 2. Design an App using the principles of Design Thinking 3. Develop an App for Android and Collaborate with other developers using git version control method 4. Learn the basics of marketing and customer support through their website	

Name of the Programme: MSc Integrated
Course Code: IMC- 801
Title of the Course: Reinforcement Learning
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Programme prerequisites, Machine Learning	
Objectives	To enable the student to understand the reinforcement learning paradigm, to be able to identify when an RL formulation is appropriate, to understand the basic solution approaches in RL, to implement and evaluate various RL algorithms.	
Content	Review of ML fundamentals – Classification, Regression. Review of probability theory and optimization concepts. RL Framework; Supervised learning vs. RL; Explore-Exploit Dilemma; Examples. MAB: Definition, Uses, Algorithms, Contextual Bandits, Transition to full RL, Intro to full RL problem	12 hours
	Intro to MDPs: Definitions, Returns, Value function, Q-function. Bellman Equation, DP, Value Iteration, Policy Iteration, Generalized Policy Iteration. Evaluation and Control: TD learning, SARSA, Q-learning, Monte Carlo, TD Lambda, Eligibility Traces. Maximization-Bias & Representations: Double Q learning, Tabular learning vs. Parameterized, Q-learning with NNs Function approximation: Semi-gradient methods, SGD, DQNs, Replay Buffer.	12 hours
	Policy Gradients: Introduction, Motivation, REINFORCE, PG theorem, Introduction to AC methods Actor-Critic Methods, Baselines, Advantage AC, A3C Advanced Value-Based Methods: Double DQN, Prioritized Experience Replay, Dueling Architectures, Expected SARSA. Advanced PG/A-C methods: Deterministic PG and DDPG, Soft Actor-Critic (SAC) HRL: Introduction to hierarchies, types of optimality, SMDPs, Options, HRL algorithms POMDPS: Intro, Definitions, Belief states, Solution Methods; History-based methods, LSTMS, Q-MDPs, Direct Solutions, PSR.	12 hours
	Model-Based RL: Introduction, Motivation, Connections to Planning, Types of MBRL, Benefits, RL with a Learnt Model, Dyna-style models, Latent variable models, Examples, Implicit MBRL. Case study on design of RL solution for real-world problems.	12 hours
Pedagogy	Hands-on assignments / Tutorials / Peer-teaching / Presentations	
References/ Readings	1. Reinforcement learning - Introduction by Richard Sutton and Andrew barto,1992. 2. Algorithms for reinforcement learning by CsabaSzepesvari, Ronald Brachman, et al, 2010	
Course Outcomes	1. Understand reinforcement learning fundamentals. 2. Implement reinforcement learning algorithms. 3. Apply reinforcement learning to real-world scenarios. 4. Evaluate and optimize reinforcement learning agents.	

Name of the Programme: MSc Integrated
Course Code: IMC- 802
Title of the Course:Optimization Techniques for Analytics
Number of Credits: 6(4L-0T-2P)
Effective from AY: 2022-23

Prerequisites for the course:	Linear Algebra, Vector Algebra	
Objective:	• To familiarize the students with some basic concepts of optimization techniques and approaches. • To formulate a real-world problem as a mathematical programming model. • To develop the model formulation and applications are used in solving decision problems. • To solve specialized linear programming problems like the transportation and assignment problems.	
Content Theory:	**Introduction to Operations Research** Introduction-Mathematical models of Operation Research - Scope and applications of Operation Research - Phases of Operation Research study - Characteristics of Operation Research - Limitations of Operation Research.	6 hours
	Linear Programming Introduction –Properties of Linear Programming-Basic assumptions-Mathematical formulation of Linear Programming-Limitations or constraints-Methods for the solution of LP Problem-Graphical analysis of LP-Graphical LP Maximization problem-Graphical LP Minimization problem.	6 hours
	Linear Programming Model Simplex Method-Basics of Simplex Method - Formulating the Simplex Method-Simplex Method with two variables - Simplex Method with more than two variables - Big M Method.	6 hours
	Dual Linear Programming Introduction- Primal and Dual problem - Dual problem properties-Solution techniques of Dual problem - Dual Simplex method-Relations between direct and dual problem-Economic interpretation of Duality.	6 hours
	Transportation and Assignment Models Introduction:Transportation problem - Balanced - Unbalanced - Methods of basic feasible solution Optimal solution-MODI method. Assignment problem-Hungarian Method.	6 hours
	Network Analysis Basic concepts-Construction of Network-Rules and precautions-CPM and PERT Networks Obtaining critical path. Probability and cost consideration. Advantages of Network.	6 hours
	Theory of Games Introduction-Terminology-Two Person Zero-Sum game-Solution of games with saddle points and without saddle points-2X2 games-dominance principle – mX2 and 2Xn games-Graphical method.	8 hours
	Industry Perspective Research and Analytical problems on various applications of the industrial issues.	4 hours

Content Practical:	**Suggested Assignments** Implementation of simplex method(two different problems) Implementation of dual simplex method(two different problems) Implementation of hungarian method(two different problems) Finding critical path method (two different problems) Game Theory(two different problems) - Solution of the game using saddle point.(two different problems) Mini Project using any one technique	5 * 7 = 35 hours (Assignments) + 13 hours (Mini Project) = 48 hours
Pedagogy:	Assignment / Quiz	
References/ Readings	**Text Book(s)** • HamdyTaha, Operations Research, 10th edition, Prentice Hall India, 2019. • P. K. Gupta and D. S. Hira, Operations Research, S. Chand & co., 2007. **Reference Books** • S.D. Sharma (2000), Operations Research, Nath & Co., Meerut. • Maurice Solient, Arthur Yaspen, Lawrence Fridman, (2003), OR methods and Problems, New Age International Edition. • J K Sharma (2007), Operations Research Theory & Applications, 3e, Macmillan India Ltd. • P. Sankara Iyer, (2008), Operations Research, Tata McGraw-Hill. • A Ravindran, Don T Philips and James J Solberg, Operations Research: Principles and practice, 2nd edition, John Wiley and sons, 2007	
Course Outcomes	1. Apply operations research techniques like linear programming problems in industrial optimization problems. 2. Solve allocation problems using various OR methods. 3. Understand the characteristics of different types of decision making environments and the appropriate decision making approaches and tools to be used in each type. 4. Recognize competitive forces in the marketplace and develop appropriate reactions based on existing constraints and resources.	

Name of the Programme: MSc Integrated
Course Code: IMC- 803
Title of the Course: MLOps At Scale
Number of Credits: 6(4L-0T-2P)
Effective from AY: 2022-23

Prerequisites for the course	Familiarity with linear algebra, probability theory, machine learning , familiarity with python.	
Objectives	This course is aimed at anyone who wishes to explore deep learning from scratch. This course offers a practical hands on exploration of deep learning, avoiding mathematical notation, preferring instead to explain quantitative concepts through programming using python API	
Content Theory:	Introduction to MLOps Rise of the Machine Learning Engineer and MLOps-What Is MLOps?-DevOps and MLOps-An MLOps Hierarchy of Needs-Implementing DevOps-Configuring-Continuous Integration with GitHub Actions-DataOps and Data Engineering-Platform Automation-MLOps	3 hours
	MLOps Foundations-Bash and the Linux Command Line-Cloud Shell Development Environments-Bash Shell and Commands-List Files Run CommandsFiles and Navigation-Input/Output-Configuration-Writing a Script-Cloud Computing Foundations and Building Blocks-Getting Started with Cloud Computing-minimalistic python revision-Descriptive Statistics and Normal Distributions-Optimization-Machine Learning Key Concepts-Doing Data Science-Build an MLOps Pipeline from Zero	5 hours
	MLOps for Containers and Edge Devices Containers-Container Runtime-Creating a Container Running a Container-Best Practices-Serving a Trained Model Over HTTP-Edge Devices-Coral Azure Percept-TFHub-Porting Over Non-TPU Models-Containers for Managed ML Systems-Containers in Monetizing MLOps-Build Once, Run Many MLOps Workflow	5 hours
	Continuous Delivery for Machine Learning Models-Packaging for ML Models-Infrastructure as Code for Continuous Delivery of ML Models-Using Cloud Pipelines-Controlled Rollout of Models-Testing Techniques for Model Deployment	5 hours
	AutoML and KaizenML-AutoML-MLOps Industrial Revolution-Kaizen Versus KaizenML-Feature Stores-Apple's Ecosystem-Apple's AutoML: Create ML-Apple's Core ML Tools orGoogle'sAutoML and Edge Computer Vision or Azure's AutoMLor AWS AutoML-Open Source AutoML Solutions-Ludwig-FLAML-Model Explainability	5 hours
	Monitoring and Logging-Observability for Cloud MLOps-Introduction to Logging-Logging in Python-Modifying Log Levels-Logging Different Applications-Monitoring and Observability-Basics of Model Monitoring-Monitoring Drift with AWS SageMaker-Monitoring Drift with Azure ML	5 hours
	MLOps for AWS-Introduction to AWS-Getting Started with AWS Services-MLOps on AWS-MLOps Cookbook on AWS-CLI Tools-Flask Microservice-AWS Lambda Recipes-AWS Lambda-SAM Local-AWS Lambda-SAM Containerized Deploy-Applying AWS Machine Learning to the Real World	5 hours
	Machine Learning Interoperability-Why Interoperability Is Critical-	5 hours

	ONNX: Open Neural Network Exchange-ONNX Model Zoo-Convert PyTorch into ONNX -Convert TensorFlow into ONNX-Deploy ONNX to Azure-Apple Core ML-Edge Integration. Building MLOps Command Line Tools and Microservices-Python Packaging-The Requirements File-Command Line Tools-Creating a Dataset Linter Modularizing a Command Line Tool-Microservices-Creating a Serverless Function-Authenticating to Cloud Functions-Building a Cloud-Based CLI-Machine Learning CLI Workflows Machine Learning Engineering and MLOps Case StudiesUnlikely Benefits of Ignorance in Building Machine Learning Models-MLOps Projects at Sqor Sports Social Network-Mechanical Turk Data Labeling-Influencer Rank-Athlete intelligence (AI product)-The perfect techniques versus the real world-critical challenges in MLops- Ethical and unintended consequences-lack of operational excellences- focus on prediction accuracy vs the big picture	5 hours 5 hours
Content Practical:	Machine Learning in Production • A journey through Data • Data Labelling Machine Learning Data Lifecycle in Production • TFDV Exercise • Data Validation • Simple Feature Engineering • Feature Engineering Pipeline • Feature Selection • ML Metadata • Iterative Schema • Data Pipeline Components for Production ML • Feature Engineering with Weather Data • Feature Engineering with Accelerometer Data • Feature Engineering with Images Machine Learning Modeling Pipelines in Production • Intro to Keras Tuner • Hyperparameter tuning and model training with TFX • Manual Dimensionality • Algorithmic_Dimensionality • Quantization and Pruning • TensorFlow Model Analysis • Model Analysis with TFX Evaluator • Fairness Indicators • Shapley Values • Permutation Feature Importance Deploying Machine Learning Models in Production • Intro to Docker and installation -First look at Tensorflow Serving with Docker -Serve a model with TensorFlow Serving • Intro to KFP • TFX Custom Components • TFS Model Versioning • Github Actions	12 hours 12 hours 12 hours 12 hours
Pedagogy	Lectures/ tutorials/lab assignments/self-study	

References/ Readings	Main Reading :- 1. Practical MLops – Noah Gift and AlfredoDeza,O'Reilly Media, Inc, 2021. 2. Introduction to MLOps – Noah Gift and AlfredoDeza, Pragmatic AI Solutions, 2021.
Course Outcomes	1. Understand What Is MLOps and MLOps Foundations 2. Continuous Delivery for Machine Learning and Monitoring and Logging 3. MLOps for AWS-Introduction 4. Machine Learning Interoperability and Machine Learning Engineering

LIST OF ELECTIVE COURSES -

Name of the Programme: MSc Integrated
Course Code: IMC-610
Title of Course: Data Driven Web App Development
Number of Credits: 4 (2L-0T-2P
Effective from AY: 2022-23

Prerequisites for the course	Knowledge of programming	
Objectives	The course will help the learner build websites and web applications.	
Content	**Foundation in Internet Technologies** • Basic concepts in Computer Networks; Protocols • Evolution of Internet and World Wide Web (WWW) • Web Architectures & Standards • Browsers & browser-engines	3 hours
	Web page design • HTML:- markup language; XML & HTML; tag & attributes; semantic (header, main, nav, etc.) & non-semantic elements (div, span); headings, paragraphs, text-formatting tags; colors & background; tables & lists; entities, charsets; links; iframe; form & input - attributes & elements; SVG & canvas • CSS:- syntax & selectors; box model; text & font properties; display, position, z-index; float & clear; styling for images & html form elements; 2-D/3-D transform, transition, animation; responsive, adaptive & mobile-first layout; viewport & media queries • CSS library/ framework (e.g. Bootstrap, Foundation)	5 hours
	Client-side scripting • Dynamic web pages • JavaScript:- programming features; events; functions; Manipulating DOM; Beyond ECMA 4 • Javascript library/ framework (e.g. JQuery, ReactJS)	4 hours
	HTTP & Middle-ware • HTTP, Request & Response, methods & error code, • headers, URL encoding & decoding • XML, data & XPath • JSON	4 hours
	Server-side Programming • Server instance • Request handling & response creation • HTML forms & file uploads • Session management & application data • Database connectivity • AJAX • Introduction to a Server-side library and/or template engine and/or framework (e.g. PHP - Laravel; JSP - Spring)	4 hours
	Data-driven web pages • User Experience Fundamentals:- gulf of evaluation and execution; 7 fundamental & universal design principles; Design Elements (line, color, shape, form vs space, value, texture, dot, typography, movement); Visual Design Principles (scale, dominance/emphasis,	4 hours

	balance, harmony); Wireframing, Mockup & Prototype (Paper & Digital); Use of tools (e.g. Pencil, Adobe XD, Sketch and/or Figma); Interaction & Animation • Use of any data visualization library (D3.js, Chart.js):- charts, graphs, maps, diagrams; SVG; scales & visuals for multi-device • Building UI for large forms, paginated tables, etc. • JSON API & AJAX; lazy loading	
	Suggested Lab Assignments (48 hours): 1. Web page design Assignments a. Create a website on a topic given by the instructor, evaluating the website with rubrics for good web design. b. Build a website using HTML & CSS by looking at a screenshot/picture of a website component given by the instructor. c. Websites built with tables, forms, images, iframes, etc. d. A website for each of design strategies (fixed, adaptive, responsive, fluid, mobile-first, etc.). e. Assignments using css pseudo-classes & -elements; grid & flex design; understanding the CSS box model & working with the browser developer tools; CSS transformations, transitions & animations f. Assignment to create a website built with Bootstrap based on a topic given by the instructor. 2. Client-side scripting Assignments a. An assignment for understanding the programming aspects of JavaScript and working with the browser developer tools. The use of the newer features of JavaScript (after ECMA 4) is encouraged. b. An assignment working with regular expressions. A search and filter utility can be built. c. Assignments for form data processing and validation and use of HTML5 form elements. A web page with form and validated data could be put in a table. The code could be written using table DOM methods and/or HTML DOM methods and/or XML DOM methods. d. Assignments using various events (mouse, keyboard, etc. events for the form elements, drag-and-drop, window, browser, etc.). e. A web component built using HTML, CSS & JavaScript based on a existing Bootstrap component (e.g. Accordion) f. Assignment with the use of a JavaScript library (JQuery, AngularJS, ReactJS, etc.) 3. Server-side programming Assignments a. Assignments to work with HTTP headers for passing data and meta-data, cookies, localStorage b. Assignments to handle data from web forms; handling the request and response payload c. Assignment to manage web sessions d. Assignment to develop a CRUD functionality by connecting to a database; AJAX calls 4. Data-driven web pages Assignments a. Build a dashboard for tourism data or bank branch	4 * 10 = 40 + 8 (Mini Project)

	b. Build a log visualiser c. Build a interactive region-map with drill-down, drill-up d. Take an API for weather forecast api and map it onto GoogleMap/OSM map 5. Mini Project: Developing a Game with HTML, CSS & JavaScript. The game should have at least 500 lines of (HTML+Javascript) code and make use of various mouse/keyboard events	
Pedagogy	Hands-on assignments / tutorials / peer-learning / project	
References/ Readings	1. Robert W. Sebesta, "Programming the World Wide Web", Pearson Education, 8th Edition 2. https://www.w3schools.com/ 3. Steven Holzner, "HTML 5 Black Book", 1st Edition 4. https://www.tutorialspoint.com/ 5. Frank W. Zammetti, "Modern Full-Stack Development", Apress, 1st Edition (2020) 6. https://www.youtube.com/watch?v=xkBheRZTkaw "Data Visualization with D3 – Full Course for Beginners [2022]" (free course from freecodecamp.org)	
Course Outcomes	1. Learner will be able to make decision on what web technology to use and for what purpose 2. Learner will have fair idea on the popular technologies used in website development 3. Learner will appreciate the architecture of web applications and the design decision 4. Learner will be able to design web applications for data driven	

Name of the Programme: MSc Integrated
Course Code: IMC-611
Title of the Course: Cloud Computing
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Web Development, Programming	
Objectives	1. To provide students with the fundamentals and essentials of Cloud Computing. 2. To provide students a sound foundation of Cloud Computing so that they are able to start using and adopting Cloud Computing services and tools in their real life scenarios. 3. To enable students to explore some important cloud computing driven commercial systems such as Google Apps, Microsoft Azure and Amazon Web Services and other businesses cloud applications. 4. To impart knowledge in applications of cloud computing	
Content	**Introduction to Cloud Computing** Cloud Computing Overview: Characteristics – challenges, benefits, limitations, Evolution of Cloud Computing, Cloud computing architecture, Cloud Reference Model (NIST Architecture) **Infrastructure as a Service** Service Model, Characteristics, Benefits, Enabling Technologies Case Study: AWS, OpenStack **Platform as a Service** Service Model, Characteristics, Benefits, Enabling Technologies Case Studies: IBM Bluemix, GAE, Microsoft Azure **Software as a Service** Service Model, Characteristics, Benefits, Enabling Technologies Case Study: Salesforce.com, CRM, Online Collaboration Services **Data Analytics as a Service** Hadoop as a service, MapReduce on Cloud, Chubby locking Service **Introduction to Public and Private Clouds** Shared Resources – Resource Pool – Usage and Administration Portal – Usage Monitor – Resource Management– Cloud Security – Workload Distribution – Dynamic provisioning. **Storage as a service** Historical Perspective, Datacenter Components, Design Considerations, Power Calculations, Evolution of Data Centers, Cloud data storage –CloudTM	6 hours 7 hours 7 hours 7 hours 7 hours 7 hours
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	1) Kai Hwang, Geoffrey Fox, Jack J. Dongarra, Morgan Kaufmann, "Distributed and Cloud Computing: From Parallel Processing to the Internet of Things," 1st Edition, 2011. 2) Gautham Shroff, "Enterprise Cloud Computing: Technology, Architecture, Applications", Cambridge press, 2010. 3) Kris Jamsa, "Cloud Computing", Jones &Barlett Learning, 2013. 4) RajkumarBuyya, James Broberg, AndrzejGoscinski, "Cloud Computing Principles and Paradigms", John Wiley & Sons, 2011. 5) John Rhoton and RistoHaukiojal, "Cloud Computing Architectured : Solution Design Handbook", Recursive Press, 2013. 6) George Recse, "Cloud Application Architectures: Building Application and	

	Infrastructure in the Cloud" , O' Reilly Media, First Edition, 2009. 7) DinkarSitaram, GeethaManjunathan, "Moving to the Cloud: Developing Apps in the new world of Cloud Computing", Syngress, 2012. 8) Samee. U. Khan, Albert. Y. Zomaya, "Handbook on Data Centers", Springer, 2015.
Course Outcomes	1. Design, Develop & Demonstrate real-world applications from the Cloud Computing 2. The subtle architectural difference in Public and Private Clouds. 3. The requirements of various service paradigms in Cloud Computing. 4. The methods of processing multimedia elements and other information presentation concepts during multimedia communications.

Name of the Programme: MSc Integrated
Course Code: IMC-710
Title of the Course: Advanced Database Management Systems
Number of Credits: 4(2L-0T-2P)
Effective from AY: 2022-23

Prerequisites for the course	Database Management Systems	
Objectives	• To evaluate emerging architectures for database management systems. • To develop an understanding of the manner in which relational systems are implemented and the implications of the techniques of implementation for database performance. • To assess the impact of emerging database standards on the facilities which future database management systems will provide.	
Content	**Unit 1** Theoretical concepts, Relational model conformity and Integrity, Advanced SQL programming **Unit 2** Query optimization, Concurrency control and Transaction management, Database performance tuning, Distributed relational systems and Data Replication **Unit 3** Object oriented, deductive, spatial, temporal and constraint database management systems, New database applications and architectures: e.g. Data Warehousing; Multimedia; Mobility; NoSQL, Native XML databases (NXD), Document oriented databases **Unit 4** SQL standards development, Standards for interoperability and integration e.g. Web Services Unit 5 Database security - Data Encryption, redaction and masking techniques. Authentication and authorization. Database auditing	6 hours 6 hours 6 hours 6 hours
List of Experiments (Indicative)		
1.	Basic SQL Intermediate SQL Advanced SQL	6 hours
2.	ER Modeling	6 hours
3.	Database Design and Normalization	6 hours
4.	Accessing Databases from Programs using JDBC	6 hours
5.	Building Web Applications using PHP & MySQL	6 hours
6.	Indexing and Query Processing	6 hours
7.	Query Evaluation Plans	6 hours
8.	Concurrency and Transactions	6 hours
Pedagogy	Lectures/ tutorials/assignments/self-study	
References/ Readings	**Text Book:** 1. Date C. J., An Introduction to Database Systems, AddisonWesley Longman (8th Ed), 2003. 2. Silberschatz A., Korth H., and Sudarshan S., Database System Concepts, McGraw-Hill (6th Ed), 2010. **Reference Book:**	

	1. Melton, J., & Simon A., SQL 1999, Understanding Relational Language Components, Morgan Kaufmann, 2003. 2. Peter Adams : SQL: The Ultimate Guide from Beginner to Expert - Learn and Master SQL in No Time, Addison Wesley, 2016.
Course Outcomes	1. Critically assess new developments in database technology 2. Interpret and explain the impact of emerging database standards 3. Evaluate the contribution of database theory 4. Understand the practical implementations of database management systems.

Name of the Programme: MSc Integrated
Course Code: IMC-711
Title of the Course: Data Warehousing and Data Mining
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Probability and Statistics	
Objectives	Data warehousing and data mining are the essential components of decision support systems for the modern day industry and business. These techniques enable the knowledge worker (analyst, manager, executive) to make better and faster decisions. The objective of this course is to introduce the student to various Data Warehousing and Data Mining concepts and techniques. A database perspective has to be used throughout the course to introduce principles, algorithms, architecture, design and implementation of data mining and data warehousing techniques.	
Content	**Introduction and Background:** Introduction to the multidisciplinary field of data mining. Discussion on the evolution of database technology that has led to the need for data warehousing and data mining. Stress on importance of its application potential. Introduction to the different key words and techniques.	6 hours
	Data Warehousing And OLAP: Insight of data warehouse and on-line analytical processing, AggregationOperations, models for data Warehousing, star schema, fact and dimension tables Conceptualization of data warehouse and multidimensional databases. Life cycle of data warehouse development. Relationship between data warehouse and data mining.	6 hours
	Data Mining Primitives: Data preprocessing including data cleaning, data integration, data transformation. Definition and Specification of a generic data mining task. Description of Data mining query language with few example queries.	12 hours
	Association Analysis: Different methods(algorithms) for mining association rules in transaction based databases. Illustration of confidence and support. Multidimensional and multilevel association rules. Classification of association rules. Discussion on few association rule algorithms e.g. Apriori, frequent pattern growth etc.	12 hours
	Classification and Predictions: Different Classification algorithm, including C4.5, CART etc., use of genie index, decision tree induction, Bayesian classification, neural network technique of back propagation, fuzzy set theory and genetic algorithms.	12 hours
	Clustering: Partition based clustering, Hierarchical clustering, model based clustering for continuous and discrete data. Discussion on scalability of clustering algorithms. Parallel approaches for clustering.	
	Web Mining: Web usage mining, web content mining, web log attributes. Use of web mining in efficient surfing and personalization	
	Mining Complex Type of Data: Data mining issues in object oriented databases, spatial databases and multimedia databases, time series databases, and text databases.	
	Applications of Data Warehousing And Data Mining: Exploration of websites on data warehousing and data mining applications including bibliography databases, Corporate Houses and Research labs.	
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	

References/ Readings	**Main Reading:** 1. Jiawei Han and MichelineKamber, "Data Mining Concepts and Techniques," 1st Edition Indian Reprint 2001, Harcourt India Private Limited, ISBN 1-55860-489-8. 2. Margaret Dunham, "Data Mining: Introductory and Advanced Topics," 1st Edition, 2003, Prentice Hall (Pearson Publication), ISBN 0-13-088892-3. 3. Arun K Pujari, "Data Mining Techniques". University Press, 2001. **Supplementary Reading** 1. T. Mitchell, "Machine Learning", 1997, McGraw Hill. 2. S.M. Weiss and N. Indurkhya, "Predictive Data Mining", 1998, Morgan Kaufmann. 3. M. Jarke, M. Lenzerni, Y. Vassiliou, and P. Vassiladis, "Fundamentals of Data Warehouses", 2000, Springer Verlag, Isbn 3-540-65365-1.
Course Outcomes	1. Understand Data Warehousing And OLAP 2. Understand Data Mining Primitives, Association Analysis 3. Understand Classification and Predictions, Clustering 4. Web Mining, Mining Complex Type of Data and applications of data mining and data warehousing.

Name of the Programme: MSc Integrated
Course Code: IMC-712
Title of the Course: Domain Specific Predictive Analytics
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Data science fundamentals and programming background	
Objectives	It introduces theoretical foundations, algorithms, methodologies for analyzing data in various domains such Retail, Finance, Risk and Healthcare.	
Content	**Retail Analytics** Understanding Customer: Profiling and Segmentation, Modelling Churn. Modelling Lifetime Value, Modelling Risk, Market Basket Analysis. **Risk Analytics** Risk Management and Operational Hedging: An Overview, Supply Chain Risk Management, A Bayesian Framework for Supply Chain Risk Management, Credit Scoring and Bankruptcy Prediction **Financial Data Analytics** Financial News analytics: Framework, techniques, and metrics, News events impact market sentiment, Relating news analytics to stock returns **Financial Time Series Analytics** Financial Time Series and Their Characteristics, Common Financial Time Series models, Autoregressive models, Markov chain models, Time series models with leading indicators, Long term forecasting **Introduction HealthcareAnalytics** An Introduction to Healthcare Data Analytics, Electronic Health Records, Privacy-Preserving Data Publishing Methods in Healthcare, Clinical Decision Support Systems **Healthcare Data Analytics** Natural Language Processing and Data Mining for Clinical Text: Core NLP Components, Information Extraction and Named Entity Recognition, Social Media Analytics for Healthcare: Tracking of Infectious Disease Outbreaks, Readmission risk prediction. **Genomic Data Analytics** Microarray Data, Microarray Data Analysis , Genomic Data Analysis for Personalized Medicine , Patient Survival Prediction from Gene Expression Data , Genome Sequence Analysis	8 hours 8 hours 8 hours 8 hours 8 hours
Pedagogy	Lectures/ tutorials/assignments/self-study	
References/ Readings	1. Chris Chapman, Elea McDonnell Feit "R for Marketing Research and Analytics", Springer, 2015. 2. Olivia Parr Rud “Data Mining Cookbook: Modeling Data for Marketing, Risk, and Customer Relationship Management”, Wiley, 2001. 3. Chandan K. Reddy, Charu C. Aggarwal "Healthcare Data Analytics", CRC Press, 2015. 4. Rene Carmona "Statistical Analysis of Financial Data in R", Springer, 2014. 4. James B. Ayers “Handbook Of Supply Chain Management” Auerbach Publications, 2006. 5. PanosKouvelis, Lingxiu Dong, OnurBoyabatli, Rong Li "The Handbook of Integrated Risk Management in Global Supply Chains", Wiley, 2012.	

Course Outcomes	1. Understand Retail Analytics 2. Understand Risk Analytics 3. Understand Financial Data Analytics, Financial Time Series Analytics 4. Understand Healthcare Analytics, Healthcare Data Analytics and Genomic Data Analytics.

Name of the Programme: MSc Integrated
Course Code: IMC-713
Title of the Course: Image processing
Number of Credits: 6(4L-0T-2P)
Effective from AY: 2022-23

Prerequisites for the course	Programming Skills(Java/Python)	
Objectives	• To introduce the concepts of image processing and basic analytical methods to be used in image processing. • To familiarize students with image enhancement and restoration techniques. • To explain different image compression techniques. • To introduce segmentation and morphological processing techniques.	
Content	**Introduction:** Image formation model, representation, spatial and Gray Level resolution, Colour models-RGB, CMY and HIS models **Image Enhancement In Spatial Domain:** Piecewise linear transformation, Histogram equalization,Histogram specification, image averaging, spatial filters – smoothing and sharpening, Laplacian filter, sobel operator, Canny edge detector. **Image Enhancement In Frequency Domain:** 2D Discrete Fourier transform and its inverse, filtering in frequency domain, Ideal and Gaussian Low pass filters, high pass filtering, separability property 0f 2D Fourier transform, Fast Fourier Transform. **Image Segmentation:** Line detection, Edge detection, Edge linking and boundary detection, Hough Transform, Thresholding, Region based segmentation **Morphological Image Processing:** Logic operations involving binary images, Dilation and Erosion, Opening and closing, Applications to Boundary extraction, region filling, connected component extraction. **Image Compression:** Coding redundancy- Huffman coding, LZW coding, run length coding, Lossy compression – Lossy predictive coding, transform coding- DCT, bit allocation, Compression standards – JPEG, video Compression. **Image Representation:** Boundary description, Shape numbers, Fourier descriptors, Texture, principal Components based description.	12 hours 12 hours 12 hours 12 hours
	Suggested Lab Assignments – 1. Program to calculate Fourier Transform of an Image 2. Program to calculate the Grayscale Histogram of an Image 3. Program to perform Median Filtering 4. Program to obtain the Gradient Image using Sobel-Operator. 5. Program for Optimal Thresholding Segmentation. 6. Program for Border-Tracing. 7. Program for Binary Erosion. 8. Program to generate the Binary Skeleton of an Image.	**(8 * 6 = 48 hours)**
Pedagogy	Lectures/ tutorials/assignments/self-study	
References/ Readings	**Main Reading:** 1. Gonzalez and Woods, "Digital Image Processing"' 2002, Pearson education, Asia. 2. Sonka, Hlavac and Boyle Brooks/Cole, "Image Processing, Analysis, and Machine Vision", 1999, Thomson Asia Pte Ltd Singapore.	

	Supplementary Reading: 1. Jain and Rangachar, “Machine Vision”, 1999, McGraw Hill International Edition. 2. Schalkoff, John Wiley and Sons, “Digital Image Processing & Computer, 1989.
Course Outcomes	1. Explain the fundamentals of digital image and its processing 2. Perform image enhancement techniques in spatial and frequency domain. 3. Elucidate the mathematical modelling of image restoration and compression 4. Apply the concept of image segmentation.

Name of the Programme: MSc Integrated
Course Code: IMC-714
Title of the Course: Industry 4.0
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Programme prerequisites and fundamentals of data science , machine learning	
Objectives	To describe various facets of Industry 4.0, to connect questions raised by Industry 4.0 with appropriate data science techniques, to develop data science tools for Industry 4.0, and to build data-centric business models.	
Content	Introduction to Industry 4.0 – Evolution and history Pillars of Industry 4.0 Industry 4.0 – India context Supplier selection as a classification problem Manufacturing 4.0 Prognosis Quality 4.0 Inventory Optimization Dynamic Pricing Logistics 4.0 Future of Manufacturing Business Focus on new paradigm Next decade of Industry 4.	12 hours 12 hours 12 hours 12 hours
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	1. Industry 4.0: Increasing the Competitiveness of Industrial Manufacturing. Published by Intueri, 2011 2. Industry 4.0: The Industrial Internet of Things by Alasdair Gilchrist, 2011 3. The Fourth Industrial Revolution by Klaus Schwab 4. Sustainability in Manufacturing Enterprises: Concepts, Analyses and Assessments for Industry 4.0 by Ibrahim Garbie,2016 5. Industry 4.0: Managing the digital transformation by Alp ustantag, Emrycevikan, 2018.	
Course Outcomes	1. understand Evolution and history of Industry 4.0, Pillars 2. understand India context, Supplier selection as a classification problem 3. understand Manufacturing 4.0, Prognosis, Quality 4.0, Inventory Optimization, Dynamic Pricing, Logistics 4.0 4. Future of Manufacturing Business Focus on new paradigm and Next decade of Industry 4.0.	

Name of the Programme: MSc Integrated
Course Code: IMC-715
Title of the Course: Information Retrieval
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Linear Algebra, Programming skills	
Objectives	Basic and advanced techniques for text-based information systems: efficient text indexing; Boolean and vector based retrieval models; Web search including crawling.	
Content	**Overview of Information Retrieval:** Function of an IR system, Kinds of IR systems, Components of an IR system, Problems in designing an IR system.The nature of unstructured and semi-structured text.	12 hours
	Text Analysis and Indexing: Preliminary stages of text analysis and document processing, tokenization, stemming, lemmatization, stop words, phrases, Indexing: Boolean IR models, inverted files, indexing, signature files, PAT trees, Positional indices. Vector-based IR models: TF/IDF term weighing, similarity measures, test collections and issues.	12 hours
	Index construction and Compression: Postings size estimation, merge sort, dynamic indexing, positional indexes, n-gram indexes. Index compression: lexicon compression and postings lists compression. Gap encoding, gamma codes, Zipf's Law. Blocking. Extreme compression.	12 hours
	Query Processing: Query expansion: spelling correction and synonyms. Wild-card queries, permuterm indices, n-gram indices. Edit distance, soundex, language detection.	12 hours
	Matching techniques: Similarity between documents and queries, Parametric or fielded search. Document zones. The vector space retrieval model, tf.idf weighting. Scoring documents, vector space scoring, the cosine measure, efficiency considerations, reduced dimensionality approximations, Latent Semantic Indexing (LSI), random projection, Page Ranking and HITS.	
	Information Extraction: Information extraction, Named entity extraction, Question Answering. Summarization - Qualities of good summary, summary types, extract summary.	
	Evaluation of IR systems: Assessment of the performance of IR systems - Precision, Recall, F-Measure. Criteria for evaluation, measuring 'goodness', tests of IR systems. Presentation of search results, display of search results, manipulation of search results.	
	Relevance feedback: User modeling and information need: user profiling, Relevance judgments. Additional term selections to the system, Dynamic respond ally to judgments and selections, Personalization of search.	
	Taxonomy and Ontology: Creating domain specific ontology, Ontology life cycle.	

	Distributed and Parallel IR: Relationships between documents, Identify appropriate networked collections, Multiple distributed collections simultaneously. **Web Search Engines:** Web crawlers, robot exclusion, Web data mining, Metacrawler, Collaborative filtering, Web agents (web shopping, bargain finder, …), Economic, ethical, legal and political issues. **Multimedia IR:** Techniques to represent audio and visual documents, Query databases of multimedia documents, Display the results of multimedia searches.	
Pedagogy	Lectures/ tutorials/assignments/self-study	
References/ Readings	1. Managing Gigabytes, by I. Witten, A. Moffat, and T. Bell, 1999. 2. Modern Information Retrieval, by R. Baeza-Yates and B. Ribeiro-Neto, 1999. 3. Information Retrieval: Algorithms and Heuristics by D. Grossman and O. Frieder, 1998.	
Course Outcomes	1. Understand Overview of Information Retrieval 2. Text Analysis and Indexing, Index construction and Compression 3. Query Processing, Matching techniques, Information Extraction, Evaluation of IR systems, Relevance feedback, Taxonomy and Ontology 4. Distributed and Parallel IR, Web Search Engines and Multimedia IR.	

Name of the Programme: MSc Integrated
Course Code: IMC-716
Title of the Course: IoT
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Internet Technologies, Computer Organization and architecture, Operating Systems.	
Objectives	To understand the fundamentals of Internet of Things and the protocols and standards designed for IoT	
Content	Introduction to IoT: Introduction, IoT ecosystem, Applications, Challenges. Fundamentals: IoT Devices - Sensors, Actuators, and gateways, Basics of the wireless sensor network. IoT Architecture & Design: oneM2M, IoTWF, Additional Reference Models, Core functional stack, Data Management and compute stack. Communicating smart objects: Communication criteria, communication models, IoT access technologies – 3GPP MTC, IEEE 802.11, IEEE 802.15, Wireless HART, ZWave, Bluetooth Low Energy, Zigbee Smart Energy, DASH7 IoT Network Layer: IP as IoT network layer, IPv6, 6LoWPAN, 6TiSCH, RPL, CORPL, CARP IoT Transport and Application protocols: Transport Layer: TCP, UDP, DCCP, SCTP, TLS, DTLS IoT application transport methods, HTTP, CoAP, XMPP, MQTT, AMQP, DDS IoT Transport and Application protocols: Transport Layer: TCP, UDP, DCCP, SCTP, TLS, DTLS IoT application transport methods, HTTP, CoAP, XMPP, MQTT, AMQP, DDS Security in IoT: MAC802.15.4, 6LoWPAN, RPL, Application Layer security. IoT Application case study: Discuss any 3 applications of IoT	10 hours 14 hours 14 hours 10 hours
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, "IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things", CISCO Press, 2017 2. Hersent, Olivier, David Boswarthick, and Omar Elloumi, The internet of things: Key applications and protocols. John Wiley & Sons, 2011. 3. Buyya, Rajkumar, and Amir VahidDastjerdi, eds. Internet of Things: Principles and Paradigms. Elsevier, 2016.	
Course Outcomes	1. Understand IoT protocols. 2. Implement IoT communication using protocols. 3. Secure IoT communication. 4. Enable interoperability among IoT devices.	

Name of the Programme: MSc Integrated
Course Code: IMC-717
Title of the Course: Numerical Methods
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Basic knowledge of multivariate calculus and elementary real analysis	
Objectives	Aimed at imparting numerical techniques required for dealing with data of scientific applications and builds Foundations for solving equations for Machine Learning models	
Content	**Root finding:** Functions and polynomials, zeros of a function, roots of a nonlinear equation, bracketing, bisection, secant, and Newton-Raphson methods. Interpolation, splines, polynomial fits, Chebyshev approximation. **Numerical Integration and Differentiation:** Evaluation of integrals, elementary analytical methods, trapezoidal and Simpson's rules, Romberg integration, Gaussian quadrature and orthogonal polynomials, multidimensional integrals, summation of series, Euler-Maclaurin summation formula, numerical differentiation and estimation of errors. **Optimization:** Extremization of functions, simple search, Nelder-Mead simplex method, Powell's method, gradient-based methods, simulated annealing. **Complex analysis:** Complex numbers, functions of a complex variable, analytic functions, conformal mapping, Cauchy's theorem. Calculus of residues. Fourier and Laplace Transforms, Discrete Fourier Transform, z transform, Fast Fourier Transform (FFT), multidimensional FFT, basics of numerical optimization.	10 hours 14 hours 10 hours 14 hours
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	• Richard L. Burden and J. Douglas Faires, Numerical Analysis: Theory and Applications, India Edition, Cengage Brooks-Cole Publishers, 2010. • Press, W.H., Teukolsky, S.A., Vetterling, W.T., and Flannery, B.P., Numerical Recipes in C/FORTRAN, Prentice Hall of India, New Delhi, 1994. • Borse, G.J., Numerical Methods with MATLAB: A Resource for Scientists and Engineers, PWS Publishing Co., Boston, 1997.	
Course Outcomes	1. Understand and apply numerical algorithms. 2. Implement numerical methods for problem-solving. 3. Analyze and quantify numerical errors. 4. Apply numerical methods to real-world problems.	

Name of the Programme: MSc Integrated
Course Code: IMC - 910
Title of Course: Programming Paradigms
Number of Credits: 4 (4L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Knowledge of programming	
Objectives	To learn and understand various programming paradigms.	
Content	**Understanding Programming Paradigm** • Programming paradigm concept, motivation, types and classification of paradigms. • Factors with respect to programming languages: Binding times and flexibility; Scoping; First class values; Abstraction; Typing; Storage Allocation & Dynamic Memory	6 hours
	Imperative Programming • Variables and data types; Operators and expressions; Input/Output operations, Decision constructs; Looping constructs • Procedural (*in Python/C*) -- blocks & scope; procedures (functions) • Object Oriented (*in Java/C++*) -- classes & objects, object-oriented principles (encapsulation, abstraction, inheritance, polymorphism)	6 hours
	Functional Programming (*in Haskell/Clojure/Scala*) • Revision of mathematical Functions' concepts • Side effects; Pure functions • Type induction • Defining functions • Currying; Function composition • Recursion • Lazy evaluation; infinite lists • List comprehensions • Higher order functions; Folds	10 hours
	Logic Programming (*in Prolog/ECLiPSe Constraint language*) • Revision of mathematical Logic concepts • Programming "without algorithms" • Logic programming with facts, rules and goals • Recursion; Lists • Constraint logic programming; constraints as relationship between variables; solving puzzles (like sudoku)	10 hours
	Event-driven Programming (*in Python/.NET*) • Events • Main loop & callback • Scheduler & Event handlers; Triggers • Exception handling • Reliable eventing • Asynchronous triggers	8 hours
	Multi-Paradigms and more • Language support for multi paradigms; Benefits & issues • Parallel programming -- Data Parallelism (*in OpenMP*) and Message Passing (*in MPI*) • Reactive programming (*in Elm/ReactiveX for Java, JS*) • Meta programming (*in Lisp*)	8 hours

	• Natural Language Programming (*in SciLab/MATLAB*)	
Pedagogy	Hands-on assignments / tutorials / peer-teaching / pair programming/ reading research papers/ presentations	
References/ Readings	• Terrance W. Pratt, Marvin V. Zelkowitz, "Programming Languages - Design & Implementation" • Robert L. Sebesta, "Concepts of Programming Languages" • Ravi Sethi, "Programming Languages Concepts & Constructs" • Bruce J. Mac Lennan, "Principles of Programming Languages: Design, Evaluation, and Implementation" • Kenneth C. Louden, "Programming Languages: Principles and Practice" • Allen Tucker, Robert Noonan, "Programming Languages: Principles and Paradigms" • Graham Hutton, "Programming in Haskell" • W. Clocksin, "Programming in Prolog" • Slim Abdennadher, Thom Frühwirth, "Essentials of Constraint Programming" • Roland Kuhn, Brian Hanafee, Jamie Allen, "Reactive Design Patterns"	
Course Outcomes	1. Learner will be able to distinguish between different programming paradigms 2. Learner will be able to choose an adequate programming paradigm in solving specific software engineering problems 3. Learner will be able to recognize the similar concepts 4. How they are implemented in a different way across different programming languages and paradigms	

Name of the Programme: MSc Integrated
Course Code: IMC-911
Title of the Course: Sequential Decision Making
Number of Credits:4(4L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Machine learning	
Objectives	Introductory level course for sequential decision making. It helps learners to find a stopping rule that optimizes the decision in terms of minimizing losses or maximizing gains , including observation costs.	
Content	Introduction to Online Learning, Halving algorithm Online Machine Learning; Perceptron and Winnow Intro to Regret; Online learning with expert advice - Hedge algorithm Online linear optimization Online convex optimization; Online learning summary Introduction to Multi armed Bandits - EXP3 Contextual MAB - EXP4 Stochastic MAB, Epsilon Greedy, Explore then commit Stochastic MAB, UCB, Thompson Sampling Stochastic MAB - Linear Bandits - LinUCB algorithm; MAB summary Introduction to Reinforcement Learning - Markov Decision Process Q-learning	12 hours 12 hours 12 hours 12 hours
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	1. Sequential decision making problems by cedricpralet,Thomasschiex,Gerard. 2. Introduction to sequential decision making by yanchen, chiicyuwang,Rayliu.	
Course Outcomes	1. Understand the differences between the various sequential decision making problems based on the type of feedback involved 2. Recognize practical ML problems as sequential decision making problems whenever they are 3. Learn about optimal algorithms for several sequential decision making settings 4. Apply the algorithms studied in the course to various practical sequential decision making scenarios.	

Name of the Programme: MSc Integrated
Course Code: IMC-912
Title of the Course: Soft Computing
Number of Credits: 6(4L-0T-2P)
Effective from AY: 2022-23

Prerequisites for the course	Machine Learning	
Objectives	The objective of this course is to introduce methods for handling imprecise and uncertain data using Rough sets, Neuro Fuzzy Systems and foster their abilities in designing and implementing optimal solutions for real-world and engineering problems using derivative free optimization techniques.	
Content	**Module: 1 Introduction to Soft Computing** Soft Computing Overview – Uncertainty in data, Hard vs Soft Computing **Module: 2 Neural Networks** Introduction, RBF Networks, Self-Organizing Map, Boltzmann Machines, Convolutional Neural Networks. **Module: 3 Fuzzy Systems** Fuzzy Sets, Fuzzy Relations, and Membership functions, Properties of Membership functions, Fuzzification and Defuzzification. **Module: 4 Fuzzy logic** Fuzzy Rule based systems, Fuzzy Decision making, Fuzzy Classification, Fuzzy CMeans Clustering. **Module: 5 Rough Sets** Rough Sets – Definition, Upper and Lower Approximations, Boundary Region, Decision Tables and Decision Algorithms. Properties of Rough Sets. Rough K-means clustering, Rough **Module: 6 Optimization Techniques** Introduction, Genetic Algorithm, Memetic Algorithms, Particle Swarm Optimization, Ant Colony Optimization, Frog-Leaping. **Module: 7 Hybrid Systems** GA Based Back Propagation Networks, Fuzzy Back Propagation Networks, Evolutionary Ensembles	8 hours 10 hours 10 hours 10 hours 10 hours
	Any 6 to be implemented in any programming language. • Develop Fuzzy Decision-Making for Job Assignment Problem • Implement TSP using Optimization Techniques • Develop a suitable method for Health Care Application using Neuro- Fuzzy Systems • Develop a suitable method for Face Recognition System • Layout Optimization using Genetic Algorithms • Fault Diagnosis using rough set theory • Software safety analysis using rough sets A Neuro-fuzzy Approach to Bad Debt Recovery in Healthcare	6 * 8 = 48 hour
Pedagogy	Assignment / Quiz / Project / Seminar	
References/ Readings	Main Readings 1. S.N. Sivanandham and S.N.Deepa, “Principles of Soft Computing”, 2nd Edition, Wiley Publications. 2. Andries P. Engelbrecht, "Computational Intelligence: An Introduction", John Wiley & Sons,2007. 3. Laurene V. Fausett “Fundamentals of Neural Networks: Architectures, Algorithms And Applications”, Pearson,1993.	

	4. Simon Haykin "Neural Networks and Learning Machines" Prentice Hall,2008. Timothy Ross, “Fuzzy Logic with Engineering Applications”, Third Edition,Wiley.
Course Outcomes	1. Have a general understanding of soft computing methodologies, to deal with imprecise and uncertain data 2. Develop computational neural network models for some simple biological systems; 3. Develop fuzzy models for engineering systems, particularly for control systems; 4. Apply derivative free optimization methods to solve real world problems Demonstrate some applications of computational intelligence Student Learning Outcomes (SLO):

Name of the Programme: MSc Integrated
Course Code: IMC-913
Title of the Course: Streaming processing and Analytics
Number of Credits: 6(4L-0T-2P)
Effective from AY: 2022-23

Prerequisites for the course	None	
Objectives	It introduces theoretical foundations, algorithms, methodologies, and Applications of streaming data and also provides practical knowledge for handling and analyzing streaming data.	
Content	**Module:1 Introduction** Characteristics of the data streams, Challenges in mining data streams Requirements and principles for real time processing, Concept drift Incremental learning. **Module:2 Data Streams** Basic Streaming Methods, Counting the Number of Occurrence of the Elements in a Stream, Counting the Number of Distinct Values in a Stream, Bounds of Random Variables, Poisson Processes, Maintaining Simple Statistics from Data Streams, Sliding Windows, Data Synopsis, Change Detection: Tracking Drifting Concepts, Monitoring the Learning Process **Module:3 Decision Trees** The Very Fast Decision Tree Algorithm (VFDT), The Base Algorithm, Analysis of the VFDT Algorithm, Extensions to the Basic Algorithm: Processing Continuous Attributes, Functional Tree Leaves, Concept Drift. **Module:4 Clustering from Data Streams** Clustering Examples: Basic Concepts, Partitioning Clustering - The Leader Algorithm, Single Pass k-Means, Micro Clustering, Clustering Variables: A Hierarchical Approach **Module:5 Frequent Pattern Mining** Mining Frequent Itemsets from Data Streams- Landmark Windows, Mining Recent Frequent Itemsets, Frequent Itemsets at Multiple Time Granularities Sequence Pattern Mining- Reservoir Sampling for Sequential Pattern Mining over data streams **Module:6 Evaluating Streaming Algorithms** Evaluation Issues, Design of Evaluation Experiments, Evaluation Metrics, Error Estimators using a Single Algorithm and a Single Dataset, Comparative Assessment, The 0-1 loss function, Evaluation Methodology in Non-Stationary Environments, The Page-Hinkley Algorithm. **Module:7 Complex Event Processing** Introduction to Complex Event Processing, Features of CEP, Need for CEP, CEP Architectural Layers, Scaling CEP, Events, Timing and Causality, Event Patterns, Rules and Constraint, STRAW-EPL, Complex Events and Event Hierarchies	8 hours 8 hours 8 hours 8 hours 8 hours 8 hours
Pedagogy	Assignment / Quiz / Project / Seminar	
References/ Readings	1. Joao Gama, “Knowledge Discovery from Data Streams”, CRC Press, 2010. 2. David Luckham, “The Power of Events: An Introduction to Complex Event Processing in Distributed Enterprise Systems”, Addison Wesley, 2002. 3. Charu C. Aggarwal, “Data Streams: Models And Algorithms”, Kluwer Academic	

	Publishers, 2007.
CourseOutcomes	1. Recognize the characteristics of data streams that make it useful to solve real-world problems. 2. Identify and apply appropriate algorithms for analyzing the data streams for a variety of problems. 3. Implement different algorithms for analyzing the data streams 4. Identify the metrics and procedures to evaluate a model

Name of the Programme: MSc Integrated
Course Code: IMC-914
Title of the Course: Text Analytics and Text Mining
Number of Credits: 6(4L-0T-2P)
Effective from AY: 2022-23

Prerequisites for the course	Machine Learning, Probability and Statistics.	
Objectives	Widely used in knowledge-driven organizations, text mining is the process of examining large collections of documents to discover new information or help answer specific research questions. Text mining identifies facts, relationships and assertions that would otherwise remain buried in the mass of textual big data.	
Content	An overview of natural language processing techniques and text representation, which are the foundation for all kinds of text-mining applications, and word association mining with a particular focus on mining one of the two basic forms of word associations (i.e., paradigmatic relations)	6 hours
	Word association mining with a particular focus on mining the other basic form of word association (i.e., syntagmatic relations), and start learning topic analysis with a focus on techniques for mining one topic from text.	6 hours
	Topic analysis in depth, including mixture models and how they work, Expectation-Maximization (EM) algorithm and how it can be used to estimate parameters of a mixture model, the basic topic model, Probabilistic Latent Semantic Analysis (PLSA), and how Latent Dirichlet Allocation (LDA) extends PLSA.	12 hours
	Text clustering, including the basic concepts, main clustering techniques, including probabilistic approaches and similarity-based approaches, and how to evaluate text clustering. You will also start learning text categorization, which is related to text clustering, but with predefined categories that can be viewed as pre-defining clusters.	12 hours
	Various methods for text categorization, including multiple methods classified under discriminative classifiers, and you will also learn sentiment analysis and opinion mining, including a detailed introduction to a particular technique for sentiment classification (i.e., ordinal regression). Sentiment analysis and opinion mining with a focus on Latent Aspect Rating Analysis (LARA), and you will learn about techniques for joint mining of text and non-text data, including contextual text mining techniques for analyzing topics in text in association with various context information such as time, location, authors, and sources of data	12 hours
	Suggested Lab Assignments 1. Programming exercises to understand the basic library of python-NLTK, Numpy and Scipy Write program to implement naïve bayes classifier. 2. Write program to implement hierarchical clustering 3. Write a program to implement a back propagation model of a neural network. 4. Write program to implement forward algorithm of HM 5. Write a program to implement the Viterbi algorithm of HMM. 6. Write program to implement baum Welsh	**(8 * 6 = 48 hours)**

	7. Document level sentiment analysisand Sentence level sentiment analysis 8. Aspect based sentiment analysis	
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	1. Natural Language Processing with Python by Steven Bird, Ewan Klein and Edward Loper. 2. Text Mining with R by Julia Silge and David Robinson. 3. Taming Text by Grant Ingersoll, Thomas Morton and Drew Farris. 4. Deep Learning in Natural Language Processing by Li Deng, Yang Liu.	
Course Outcomes	1. Understand artificial intelligence (AI) technology that uses natural language processing (NLP) 2. Understand how to transform the free (unstructured) text in documents 3. Understand how to transform databases into normalized, structured data suitable for analysis or 4. To drive machine learning (ML) algorithms.	

Name of the Programme: MSc Integrated
Course Code: IMC-915
Title of the Course: Video Analytics
Number of Credits: 4(4L-0T-0P)
Effective from AY: 2022-23

Prerequisites for the course	Image Processing, Probability, Linear Algebra.	
Objectives	The main goal of video analytics is to automatically recognize temporal and spatial events in videos. A person who moves suspiciously, traffic signs that are not obeyed, the sudden appearance of flames and smoke; these are just a few examples of what a video analytics solution can detect.	
Content	Revisit to Digital Image and Video Processing Camera Models Background Modelling Object Detection and Recognition Local Feature Extraction Biologically Inspired Vision Object Classification Segmentation Object Tracking Activity Recognition Anomaly Detection Handling Occlusion Scale and Appearance changes Other Applications	12 hours 12 hours 12 hours 12 hours
Pedagogy	Lectures/ Tutorials/Hands-on assignments/Self-study	
References/ Readings	1. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer 2010. 2. Forsyth, D.A., and Ponce, J., Computer Vision: A Modern Approach, Pearson Education, 2003.	
Course Outcomes	1. Understand Digital Image and Video Processing 2. Camera Models, Background Modelling, 3. Object Detection and Recognition, Local Feature Extraction, Biologically Inspired Vision, Object Classification, Segmentation, Object Tracking, Activity Recognition 4. Anomaly Detection, Handling Occlusion, Scale and Appearance changes and Other Applications.	