

BABU BANARASI DAS UNIVERSITY, LUCKNOW

Department of Mathematics & Computer Science School of Basic Sciences

B.Sc. (Hons./Hons. with research) Computer Science

(Effective from Academic Session 2023-24, as per NEP-2020)

Semester	Major Core Course (DSC) 4 Credits	Major Elective Course (DSE) 4 Cr	Minor Course (GE) 4 Credits	Co-Curricular Course (CC) 3 Credits	Vocational Course (VC) 2 Credits	Apprenticeship/ Internship/ Project/ Community Outreach/ MOOC (AIPCM) 2 Credits	Major Project/ Dissertation/ Academic Project 6 Credits	General Proficiency (GP) / Seminar 1 Credit	Total Credit
I	DSC1 DSC2 DSC3		GE1	CC1	VC1			1	22
II	DSC4 DSC5 DSC6		GE2	CC2	VC2			1	22
III	DSC7 DSC8 DSC9		GE3	CC3	VC3 Or AIPCM			1	22
IV	DSC10 DSC11 DSC12		GE4	CC4	VC4 Or AIPCM			1	22
V	DSC13 DSC14 DSC15	DSE1	GE5	VC5 Or AIPCM					22
VI	DSC16 DSC17 DSC18	DSE2	GE6			Project/ Dissertation 2 Credit			22
VII	DSC19	Three DSE or Two DSE and One GE or One DSE and Two GE					Dissertation/ Academic Project/ Internship		22
VIII	DSC20	Three DSE or Two DSE and One GE or One DSE and Two GE					Dissertation/ Academic Project/ Internship		22

List of Discipline Specific Core (DSC) Courses

DSC	Course Code	Course Name	Contact Hours			Marks			Cr	Exam Hrs.
			L	T	P	CIA	ESE	Total		
DSC1	NBSC3101	Computer Fundamentals & Programming Technique	3	1	-	40	60	100	4	3
DSC2	NBSC3102	Programming using C	3	-	-	40	60	100	3	3
	NBSC3151	Programming using C LAB	-	-	2	40	60	100	1	3
DSC3	NBSC3103	Computer Organisation & Architecture	3	1	-	40	60	100	4	3
DSC4	NBSC3201	Data Structure using C	3	-	-	40	60	100	3	3
	NBSC3251	Data Structure using C LAB	-	-	2	40	60	100	1	3
DSC5	NBSC3202	Operating System	3	1	-	40	60	100	4	3
DSC6	NBSC3203	Computer Networks	3	1	-	40	60	100	4	3
DSC7	NBSC3301	Java Programming	3	-	-	40	60	100	3	3
	NBSC3351	Java Programming LAB	-	-	2	40	60	100	1	3
DSC8	NBSC3302	Discrete Structures	3	1	-	40	60	100	4	3
DSC9	NBSC3303	Design & Analysis of Algorithms	3	1	-	40	60	100	4	3
DSC10	NBSC3401	Database Management System	3	-	-	40	60	100	3	3
	NBSC3451	Database Management System LAB	-	-	2	40	60	100	1	3
DSC11	NBSC3402	Programming Concept with Python	3	-	-	40	60	100	3	3
	NBSC3452	Python Programming LAB	-	-	2	40	60	100	1	3
DSC12	NBSC3403	Artificial Intelligence	3	1	-	40	60	100	4	3
DSC13	NBSC3501	Web Technologies	3	-	-	40	60	100	3	3
	NBSC3551	Web Technologies LAB	-	-	2	40	60	100	1	3
DSC14	NBSC3502	Information Security and Cyber Law	3	1	-	40	60	100	4	3
DSC15	NBSC3503	Software Engineering	3	1	-	40	60	100	4	3
DSC16	NBSC3601	Machine Learning	3	1	-	40	60	100	4	3
DSC17	NBSC3602	Cloud Computing	3	1	-	40	60	100	4	3
DSC18	NBSC3603	Soft Computing	3	1	-	40	60	100	4	3
DSC19	NBSC3701	Internet of Things	3	1	-	40	60	100	4	3
DSC20	NBSC3801	Digital Image Processing	3	1	-	40	60	100	4	3

List of Discipline Specific Elective (DSE) Courses

DSE	Course Code	Course Name	Contact Hours			Marks			Cr	Exam Hrs.
			L	T	P	CIA	ESE	Total		
DSE1A	NBSCE3501	Fundamental of Data Science	3	1	-	40	60	100	4	3
DSE1B	NBSCE3502	Computer Vision	3	1	-	40	60	100	4	3
DSE1C	NBSCE3503	Block chain Technology	3	1	-	40	60	100	4	3
DSE2A	NBSCE3601	E-Commerce	3	1	-	40	60	100	4	3
DSE2B	NBSCE3602	Management Information System	3	1	-	40	60	100	4	3
DSE2C	NBSCE3603	Research Methodologies	3	1	-	40	60	100	4	3
DSE3A	NBSCE3701	Big Data Analysis	3	1	-	40	60	100	4	3
DSE3B	NBSCE3702	Data mining & Ware Housing	3	1	-	40	60	100	4	3
DSE3C	NBSCE3703	Distributed Data Base System	3	1	-	40	60	100	4	3
DSE3D	NBSCE3704	Mobile Computing	3	1	-	40	60	100	4	3
DSE4A	NBSCE3801	Sentiment Analysis	3	1	-	40	60	100	4	3
DSE4B	NBSCE3802	Augmented & Virtual Reality	3	1	-	40	60	100	4	3
DSE4C	NBSCE3803	Neural Networks	3	1	-	40	60	100	4	3
DSE4D	NBSCE3804	Expert System	3	1	-	40	60	100	4	3

List of Minor Course (GE)

GE	Course Code	Course Name	Contact Hours			Marks			Cr	Exam Hrs.
			L	T	P	CIA	ESE	Total		
GE1A	NBSM3103	Calculus	3	1	-	40	60	100	4	3
GE1 B	NBBA5102	Business Environment	3	1	-	40	60	100	4	3
GE1 C	NBSE1101	Descriptive Statistic	3	1	-	40	60	100	4	3
GE2 A	NBSM3202	Ordinary Differential Equations	3	1	-	40	60	100	4	3
GE2 B	NBBA5203	Business Organisation	3	1	-	40	60	100	4	3
GE2 C	NBSE1201	Probability & Distribution	3	1	-	40	60	100	4	3
GE3 A	NBSM3303	Partial Differential equations	3	1	-	40	60	100	4	3
GE3 B	NBBA5302	Rural Management	3	1	-	40	60	100	4	3
GE3 C	NBSE1301	Statistical Inference	3	1	-	40	60	100	4	3
GE4 A	NBSM3403	Graph Theory	3	1	-	40	60	100	4	3
GE4 B	NBBA5402	Human Resource Management and Development	3	1	-	40	60	100	4	3
GE4 C	NBSE1401	Survey Sampling	3	1	-	40	60	100	4	3
GE5 A	NBSM3503	Numerical Analysis	3	1	-	40	60	100	4	3
GE5 B	NBBA5501	Business Policy and Strategies	3	1	-	40	60	100	4	3
GE5 C	NBSE1501	Analysis of Variance & Design of Experiment.	3	1	-	40	60	100	4	3
GE6 A	BSME3602	Boolean Algebra & Automata Theory	3	1	-	40	60	100	4	3
GE6 B	NBBA5602	Entrepreneurship & Small business Management	3	1	-	40	60	100	4	3
GE6 C	NBSE1601	Operations Research	3	1	-	40	60	100	4	3
GE7 A	NBSM3701	Discrete Mathematics	3	1	-	40	60	100	4	3
GE7 B	NBBA5703	Income tax Law & Practices	3	1	-	40	60	100	4	3
GE7 C	NBSE1701	Optimization Techniques	3	1	-	40	60	100	4	3
GE8 A	NBSM3801	Ordinary and Partial Differential Equations	3	1	-	40	60	100	4	3
GE8 B	NBBA5801	Banking Insurance	3	1	-	40	60	100	4	3
GE8 C	NBSE1801	Applied Statistics	3	1	-	40	60	100	4	3

Program	B.Sc. (Hons./ Hons. with Research) Computer Science				
Year	1	Semester	I		
Course Name	Computer Fundamentals & Programming Techniques				
Code	NBSC3101				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic knowledge of computer and its operations	3	1	-	4
Course Objectives	The main objective of the course is to provide basic concept of computer hardware and Software. Students also able to solve various kinds of real life problems using various problem solving Techniques and understand the concept of basics of programming.				
Course Outcomes					
CO1	To understand basic concepts of hardware technologies				
CO2	To understand basic concepts of System Software and Applications Software.				
CO3	To understand and solve the problem using various types of problem solving techniques.				
CO4	To understand the basic concept of Programming Techniques.				
Module	Course Contents			Contact Hrs.	Mapped CO
1	Introduction to computer: Introduction, Basic block diagram and functions of various components of computer, Concept of Hardware: Input/output Devices, Computer Memories: Primary Memory and Secondary Memory, CPU Registers. Concepts Of Machine Level, Assembly Level And High Level Programming, ([1] Chapter 2).			15	CO1
2	Software: Software and its needs, Types of Software. System Software: Operating System, Utility Programs Programming Language: Machine Language, Assembly Language, High Level Language their advantages & disadvantages. Application of Software and its types: Word Processing, Spread Sheets Presentation, Graphics, DBMS software. ([3] Chapter 6).			15	CO2
3	Problem Solving Techniques: Problem Definition, Problem Solving Using Divide And Conquer, Brain Storming And Trial & Error, Steps In Problem Solving: Define Problem Analyze Problem And Explore Solution.			15	CO3
4	Algorithms, Building Blocks Of Algorithms, Statements, Control Flow, Characteristics of Algorithms, Examples. Pseudo Code, Flow Chart, Notations, Examples. ([2] Chapter 1). Introduction To Programming: Basic Difference Between			15	CO4

	Procedure Oriented Language And Object Oriented		
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Suggested Readings

1. Computer Fundamentals by P.K.Sinha.
2. Jeri R. Hanly, Elliot B.Koffman, Problem Solving and Program Design in C Peardon
3. Object-Oriented Programming in C++ By Robert Lafore · 1997

Online Resources

1. <https://nptel.ac.in/courses/106105171>
2. https://onlinecourses.swayam2.ac.in/cec21_cs15/preview

PO-PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	1		1			1		1			2		2	1
CO 2	1							1			1		2	1
CO 3						1		1					2	
CO 4	1	1				1		1					2	1

Program	B.Sc. (Hons./ Hons. with Research) Computer Science				
Year	1	Semester		I	
Course Name	Programming using C				
Code	NBSC3102				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic knowledge of computer and its operations	3		-	3
Course Objectives	The course is designed to provide complete knowledge of C language. Students will be able to develop logics which will help them to create programs, applications in C. Also by learning the basic programming constructs they can easily switch over to any other language in future				
Course Outcomes					
CO1	To learn and develop simple algorithms to solve various types of problems and develop problem solving skills coupled with Top-Down design principles.				
CO2	To learn the strategies of writing efficient and well-structured computer programs and develop the skills for formulating Iterative solutions to various problems.				
CO3	To learn various types of Operators and Functions in C programming and learn the concept of single and multi-dimensional Arrays & various Searching and Sorting techniques.				
CO4	To enhance the learning of C programming by using Pointers & various types of Dynamic Memory Allocation functions.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Introduction to Programming Languages: Concept of Assembler, Compiler, Interpreter ([1] Chapter 1).The Role of Programming Languages, HLL, LLL, Programming Paradigms, Programming Environments. ([1] Chapter 1). Programming Basics: Structure of C Program, Writing and Executing the first C program, Syntax and Logical Errors in Compilation, Object and Executable Code. Components of C language: Standard I/O in C, Fundamental Data Types, Variables and Memory Locations, Storage Classes ([1] Chapter 1,2).	15	CO1
2	Arithmetic expressions & Conditional Branching: Arithmetic Expressions and Precedence, Operators and Expression using Numeric and Relational Operators, Mixed-mode Operations, Type Conversion, Logical Operators, Bit-wise Operators, Assignment Operators, Operator Precedence and Associativity. Conditional Branching: Applying if-else and Switch-case Statements, Nesting If-Else([1] Chapter 6). Loops & Functions: Iteration and Loops, While, Do-while and for Loops, Multiple Loop Variables, Break and Continue Statements ([1] Chapter 6). Functions: Introduction,	15	CO2

	Types of Functions, Functions with Array, Passing Parameters to Functions, Call by value, Call by Reference([1] Chapter 7).		
3	Arrays and Structures: Array Notation and Representation, Manipulating Array Elements, Arrays Using Multi-Dimensional, Character Arrays and Strings, Structure, Union, Enumerated Data Types, Array of Structures, Passing Arrays to Functions ([1] Chapter 9). Basic Algorithms: Searching & Basic Sorting Algorithms (Bubble and Selection).	15	CO3
4	Pointers & File Handling: Pointers: Pointers & Memory Allocation in C, Pointer to Pointer, Pointers to Structures, Problems with Pointers, Passing Pointers as Function Arguments, Using Arrays with Pointers, Passing Arrays to Functions. Static and Dynamic Memory Allocation: use of malloc(), calloc() and free() functions, Storage of Variables In Static and Dynamic Memory Allocation ([1] Chapter 10). File handling: Creating Files, various File handling modes, File I/O functions, Standard C Pre-processors, defining and calling Macros([1] Chapter 1-2).	15	CO4

Suggested Readings

1. Schaum's Outline of Programming with C by Byron Gottfried, McGraw-Hill
2. The C programming by Kernighan Brain W. and Ritchie Dennis M, Pearson Education.
3. Computer Basics and C Programming by V.Rajaraman, PHI Learning Pvt. Limited, 2015.
4. Computer Concepts and Programming in C, R.S. Salaria, Khanna Publishing House.

Online Resources

1. <https://nptel.ac.in/courses/106104128>
2. <https://nptel.ac.in/courses/106105151>

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1	1				1					1	1
CO2	1		1	1				1					1	2
CO3	1	1	1					1					1	1
CO4	1	1	1					1					1	1

Program	B.Sc. (Hons./ Hons. with Research) Computer Science				
Year	1	Semester	I		
Course Name	Programming using C Lab				
Code	NBSC3152				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic knowledge of computer and its operations			2	1
Course Objectives	The course is designed to provide Practical knowledge of C language. Students will be able to develop C language programs on various mathematical and computational problems which will help them to create applications in C.				
Course Outcomes					
CO1	To learn the basic terminology of C language, Structure of C program and writing user friendly programs.				
CO2	To learn the various kind of operators, data types, character sets which will help to create basic program of c language.				
CO3	To develop logical C language program using array loops, functions, structure and union.				
CO4	To create programs using concept of pointers, dynamic memory allocation and file handling.				

- 1.WAP to print the sum and product of digits of an Integer.
 - 2.WAP to reverse a number.
 - 3.WAP to compute the Sum of the first n terms of the following series $S = 1 + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \dots$
 - 4.WAP to compute the Sum of the first n terms of the following series $S = 1 - 2 + 3 - 4 + 5 - \dots$
 5. Write a function that checks whether a given string is Palindrome or not.
 6. Write a function to find whether a given no. is Prime or not. Use the same to generate the Prime numbers less than 100.
 - 7.WAP to compute the factors of a given number.
 8. Write a macro that Swap two numbers.
 9. WAP to perform following actions on an Array entered by the User:
 - i) Print the Even-valued elements.
 - ii) Print the Odd-valued elements.
 - iii) Calculate and print the Sum and Average of the elements of Array.
 - iv) Print the Maximum and Minimum elements of Array.
 - v) Remove the duplicates from the Array.
 - vi) Print the Array in Reverse Order.
- The Program should present a Menu to the User and ask for one of the Options.
The Menu should also include options to re-enter Array and to quit the Program.
10. WAP that prints a table indicating the number of occurrences of each alphabet in the text entered as Command line Arguments.
 11. Write a program that Swap two numbers using Pointers.
 12. Write a program in which a Function is passed address of two variables and then alter its contents.

13. Write a program which takes the radius of a circle as input from the user, passes it to another function that computes the area and the circumference of the circle and displays the value of area and circumference from the main() function.
14. Write a program to find Sum of n elements entered by the user. To write this program, Allocate memory dynamically using malloc() /calloc() functions or new Operator.
15. Write a Menu driven program to perform following Operations on strings:
 - a) Show address of each character in String.
 - b) Concatenate two strings without using strcat() function.
 - c) Concatenate two strings using strcat() function.
 - d) Compare two Strings.
 - e) Calculate length of the string (use Pointers).
 - f) Convert all Lowercase characters to Uppercase.
 - g) Convert all Upper case characters to Lowercase.
 - h) Calculate number of Vowels.
 - i) Reverse the String
16. Given two ordered Arrays of Integers, Write a program to merge the two-Arrays to get an ordered Array.
17. WAP to display Fibonacci series:
 - (i) Using Recursion.
 - (ii) Using Iteration.
18. WAP to calculate Factorial of a number:
 - (i) Using Recursion.
 - (ii) Using Iteration.
19. Create a Structure Student containing fields for Roll No., Name, Class, Year and Total Marks. Create 10 such Students and store them in a file.
20. Copy the contents of one text file to another file, after removing all Whitespaces.
21. Write a function that reverses the elements of an Array in place. The function must accept only one Pointer value and return void.
22. Write a program that will read 10 integers from user and store them in an array. Implement array using pointers. The program will print the array elements in ascending and descending order.
23. Write a Program to create a file & store information.
24. Write a C Program to illustrate reading of data from a File.
25. Write a C Program delete a specific Line from a text File.

PO- PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	1	1	2	1		2	1	3	1		1		1	1
CO2	1	1	3	1		2	2	3	1		1		1	2
CO3	1	1	2	1		3	1	3	2		1		1	1
CO4	1	1	3	1		3	2	3	2		1		2	1

Program	B.Sc. (Hons./ Hons. with Research) Computer Science				
Year	1	Semester	I		
Course Name	Computer Organisation & Architecture				
Code	NBSC3103				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic knowledge of computer and its operations	3	1	-	4
Course Objectives	To study of the basic structure and operation of a digital computer system. To understand how computer are constructed by a set of functional units. To Analyzing fundamental issues in architecture design and their impact on application performance				
Course Outcomes					
CO1	To Identify the basic structure and function unit of a digital Computer.				
CO2	To understanding and analyze the effect of addressing modes and instructions.				
CO3	To understand Control Unit and ALU				
CO4	To understand Interrupts and I/O				
Module	Course Contents			Contact Hrs.	Mapped CO
1	Computer Evolution and Arithmetic: A historical evolution of computers: Von Neumann Architecture, Hardware Architecture, Bus Interconnection, Register Transfer Language, Bus and Memory Transfers, Bus Architecture, Bus Arbitration Techniques, Arithmetic Logic, Shift Micro Operation, Arithmetic Logic Shift Unit, Arithmetic Algorithms(Addition, Subtraction, Both Multiplication, Division) ([1] Chapter 4).			15	CO1
2	Control Unit: Control Design: Hardwired and Soft wired logic, Micro programmed logic, Performing of Arithmetic and Logical Operations, Multiple Bus Organization, Hardwired Control, Micro Programmed Controlled, Micro-Instructions, Micro Programmed Sequencing, Wide-Branch Addressing, Micro Instruction with next- Address Field, Pre-fetching, Micro Instruction, Block diagram of Microprocessor, Pipelining, Pipeline Control Instructions Pipeline, Pipeline Performance. ([1] Chapter 8).			15	CO2
3	Processor Organisation and Input/ Output Organisation: Processor Design: General Register Organisation, Stack Organisation, Addressing Modes, Instruction Format, Data Transfer and manipulations, Programmed controlled, Reduced Instruction Set, ([2] Chapter13). Computer Memory Organisation: Basic			15	CO3

	Concept and Hierarchy, Semi-Conductor memories, Concept and Design Issues and Performance, Address Mapping and Replacement, Auxiliary Memories: Magnetic Disk, Magnetic Tape, Optical Disk, Virtual Memory, concept Implementation. ([2] Chapter 5-6).		
4	Interrupts: Interrupt Hardware, Types of Interrupts and Exceptions, Modes of Data Transfer: Programmed I/O, Interrupt initiated I/O, Direct Memory Access: I/O Channels and Processors, Serial Communication: Synchronous & Asynchronous Communication, Standard Communication Interfaces. ([2] Chapter 7).	15	CO4

Suggested Readings

1. Computer System Architecture, by Moris Mano
2. Computer Organization And Architecture Designing For Performance, By William Stallings

Online Resources

1. <https://nptel.ac.in/courses/106103068>
2. <https://nptel.ac.in/courses/106104073>

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

Program	B.Sc. (Hons./ Hons. with Research) Computer Science				
Year	1	Semester		II	
Course Name	Data Structures using C				
Code	BSC3201				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic knowledge of computer and its operations	3		-	3
Course Objectives	<p>Allow to assess how the choice of data structures and algorithm design methods impacts the performance of programs.</p> <p>To solve problems using data structures such as linear lists, stacks, queues, binary trees, binary search trees, and graphs and writing programs for these solutions.</p>				
Course Outcomes					
CO1	To be familiar with fundamental Data Structures and with the manner in which these Data Structures can best be implemented, become accustomed to the description of Algorithms in both functional and procedural styles.				
CO2	To have knowledge of Complexity of basic Operations like Insert, Delete, Search on these Data Structures. Ability to choose a Data Structure to suitably model any data used in Computer Applications.				
CO3	To design programs using various Data Structures including Hash tables, Binary and general Search Trees, Heaps, Graphs etc.				
CO4	Ability to assess efficiency trade-offs among different Data Structure implementations. Implement and know the applications of Algorithms for Sorting, Pattern-matching etc.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Basic concepts: Algorithm Specification-Introduction, Recursive Algorithms, Data Abstraction Performance analysis ([1] Chapter 1).Linear and Non Linear Data Structures. Linked Lists: Creating and Traversing linked-lists, Circularly Linked Lists: Operations for Circularly Linked Lists, Doubly Linked Lists-operations ([1] Chapter 4).Representation of Single, Two Dimensional Arrays, Sparse Matrices-Array and Linked Representations.([2] Chapter 4).	15	CO1
2	Stack: Operations, Array and Linked Implementations, Applications- Infix to Postfix Conversion, Postfix Expression Evaluation, Recursion implementation. Queue: Definition and Operations, Array and Linked implementations, Circular Queues-Insertion and Deletion Operations, Deque(Double Ended Queue) Priority Queue- Implementation ([2] Chapter 6).	15	CO2

3	Trees: Representation of Trees, Binary Trees, Properties of Binary Trees, Binary Tree Representations- Array and Linked Representations, Binary Tree Traversals, Threaded Binary Trees, Heap-Definition, Insertion, Deletion. Search Trees: Binary Search Trees, AVL Trees- Definition, creation and traversing. ([2] Chapter 7).	15	CO3
4	Graphs: Graph ADT, Graph Representations: Adjacency Matrix, Incidence Matrix, Graph Traversals ([2] Chapter 8). Sorting Methods, Comparison of Sorting Methods. Hashing: Introduction, Hash Tables, Hash Functions, Overflow Handling ([2] Chapter 9).	15	CO4

Suggested Readings

1. Fundamentals of Data structures in C, 2nd Edition, E. Horowitz, S. Sahni and Susan Anderson-Freed, Universities Press.
2. Lipschutz, Schaum's outline series Data structures Tata McGraw-Hi
3. Data structures and Algorithm Analysis in C, 2nd edition, M. A. Weiss, Pearson.
4. .Data structures using C and S. Tanenbaum, Y. Langsam, and M. J. Augenstein.

Online Resources

1. <https://nptel.ac.in/courses/106103069>
2. <https://nptel.ac.in/courses/106102064>

PO-PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	1	1						1					1	1
CO 2	1			1				1					1	1
CO 3	1	1	1			2		1					1	1
CO 4	1	1	1	1		1		1					1	1

Program	B.Sc. (Hons./ Hons. with Research) Computer Science				
Year	1	Semester		Second	
Course Name	Data Structures using C Lab				
Code	NBSC3251				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic knowledge of computer and its operations	-	-	2	1
Course Objectives	To solve problems using data structures such as linear lists, stacks, queues, binary trees, binary search trees, and graphs and writing programs for these solutions.				
Course Outcomes					
CO1	Student will be able to develop programs using various kinds of data structure like array and linked list				
CO2	To develop and implement programs of stack and queue data structure using array and linked list.				
CO3	Student will be able to develop logic using heterogeneous data structure like tree BST, AVL tree etc.				
CO4	Student will be able to create and implement various algorithms using graph theory.				

1. Write a program to perform Insertion and Deletion operations in an Array.
2. Write a program to multiply two 2D Matrices.
3. Write a program to Display non-zero elements from Sparse Matrix.
4. WAP to convert the Sparse Matrix into non-zero form and vice-versa.
5. Write a program to Search an element from a list. Give user the option to perform Linear or Binary search.
6. WAP using templates to Sort a list of elements. Give user the option to perform sorting using Insertion Sort, Bubble sort or Selection sort.
7. Write a program to create Queue and perform Insertion and Deletion operations.
8. Write a program to create Deque and perform Insertion and Deletion operations.
9. Write a program to create Priority Queue and perform Insertion and Deletion operations.
10. Implement Linked List using templates. Include functions for Insertion, Deletion and search of a number, Reverse the list and concatenate two Linked Lists.
11. Implement Doubly Linked-List using templates. Include functions for Insertion, Deletion and search of a number, reverse the list.
12. Implement Circular Linked List using templates. Include functions for Insertion, Deletion and search of a number, reverse the list.
13. Perform Stack operations using Linked List implementation.
14. Perform Stack operations using Array implementation.
15. Perform Queues operations using Circular Array implementation.
16. Create and perform different operations on Double-ended Queues using Linked-list implementation.
17. WAP to calculate factorial and to compute the factors of a given no. (i) using Recursion (ii) Using Iteration.
18. WAP to display Fibonacci series (ii)Using Recursion, (iii) Using Iteration

19. WAP to create a Binary Search Tree and include following operations in Tree:
20. Insertion (Recursive and Iterative Implementation).
21. Search a number in BST.
22. Display its pre-order, post-order and in-order traversals Recursively.
23. Display its pre-order, post-order and in-order traversals Iteratively.
24. Display its level-by-level traversals.
25. Count the non-leaf nodes and Leaf Nodes.
26. Display Height of Tree.
27. WAP to reverse the order of the elements in the Stack using additional Stack.
28. WAP to reverse the order of the elements in the Stack using additional Queue.
29. WAP to implement Lower Triangular Matrix using One-dimensional Array.
30. WAP to implement Upper Triangular Matrix using One-dimensional Array.
31. WAP to implement Symmetric Matrix using one-dimensional array.
32. WAP to Create a Threaded Binary Tree as per in-order Traversal, and Implement operations.

PO-PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	1	1	2	1		2	1	3	1		1		2	1
CO 2	2	1	3	1		2	2	3	1		1		1	2
CO 3	1	2	2	2		3	1	3	2		1		1	1
CO 4	1	1	3	2		3	2	3	2		1		2	1

Program	B.Sc. (Hons./ Hons. with Research) Computer Science				
Year	1	Semester		II	
Course Name	Operating System				
Code	NBSC3202				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic knowledge of computer and its operations	3	1	-	4
Course Objectives	To learn how Operating System is Important for Computer System, make aware of different types of Operating System and their services, To learn different process scheduling algorithms, synchronization and secondary memory management				
Course Outcomes					
CO1	To understand the basic concept and types of Operating System.				
CO2	To learn Operating System organization i.e. concept of process, process synchronization etc.				
CO3	To learn the various kinds of process scheduling algorithms.				
CO4	To learn file management, I/O management and protection and security policies.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Module I: Introduction: Definition of operating system, History of Operating Systems , Single user/Multi User and Single and Multitasking OS; types of operating systems–multiprogramming systems, batch systems, time sharing systems, Distributed System, real time systems; Functions of operating system: Memory management, process management, device management, file management etc.	15	CO1
2	Operating System Organization: System calls and system programs. Process Management: System view of the process and resources, process abstraction, process hierarchy, threads; Process synchronization: concurrent processes, critical sections, methods for inter-process communication; classical two process and n-process solutions, hardware primitives for synchronization, semaphores, monitors, classical problems in synchronization (producer-consumer, readers-writer, dining philosophers etc.).	15	CO2
3	Process Scheduling: non-pre-emptive and pre-emptive scheduling algorithms-FCFS, SJF, SRTF, Round Robin etc., Semaphores. Memory Management: Memory address, Physical and virtual address space; memory allocation strategies –fixed and variable partitions, Concept of paging, segmentation, demand paging, virtual	15	CO3

	memory, page replacement algorithms, virtual memory		
4	Deadlocks: prevention and avoidance, detection and recovery. File and I/O Management File concepts, Access methods, Directory structure, File system structure, files operations, files allocation methods, device management, Protection and Security, Policy mechanism, Authentication	15	CO4

Suggested Readings

1. A Silberschatz, P.B. Galvin, G. Gagne, Operating Systems Concepts, 8th Edition, John Wiley
2. Publications 2008.G. Nutt, Operating Systems: A Modern Perspective, 2nd Edition Pearson Education 1997.
3. W. Stallings, Operating Systems, Internals & Design Principles , 5th Edition, Prentice Hall of India. 2008.
4. M. Milenkovic, Operating Systems- Concepts and design, Tata McGraw Hill 1992.

Online Resources

1. <https://archive.nptel.ac.in/courses/106/105/106105214/>
2. https://onlinecourses.nptel.ac.in/noc20_cs04/preview

PO-PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	1		1	1				2						1
CO 2	1	1	1	1				1						1
CO 3	1		1					2						1
CO 4	1	1	1	1				2						1

Program	B.Sc. (Hons./ Hons. with Research) Computer Science				
Year	1	Semester		II	
Course Name	Computer Networks				
Code	NBSC3203				
Course Type	DSC	L	T	P	Credit
Pre-Requisite	Basic knowledge of computer and its operations	3	1	-	4
Course Objectives	Student will be able to learn the concept of computer networking, it's various types, reference models, layers of TCP/IP and OSI Model and various services.				
Course Outcomes					
CO1	Describe how Computer Networks are organized with the concept of layered Approach.				
CO2	Implement a simple LAN with Hubs, Bridges and Switches. Learn basic routing mechanisms, IP addressing scheme and internetworking concepts.				
CO3	Student will be able to learn the concept of multiple access control, network layer functions and protocols.				
CO4	To learn the various kind of protocols and services provided by application layer and transport layer.				
Module	Course Contents			Contact Hrs.	Mapped CO
1	Fundamentals of Computer Networks: Network Definition, Network Topologies, Network Classifications, Network Protocol, Layered Network Architecture, Reference Models: OSI Reference Model, TCP/IP Reference model ([1] Chapter 1-2), Comparison of OSI and TCP/IP Models ([1] Chapter 2).			15	CO1
2	TCP/IP Protocol Suite: TCP/Ip layers and Protocols, ([1] Chapter 2). Networks Switching Techniques and Access Mechanisms: Circuit Switching, Packet switching- Connectionless Datagram Switching, Connection-Oriented virtual Circuit Switching, Dial-up Modems, Digital Subscriber Line, Cable TV for Data transfer([1] Chapter 8).Data Link Layer Functions and Protocol: Error Detection and Error Correction Techniques, Data-link Control-Framing and Flow Control, Error Recoveries Protocols- Stop and Wait ARQ, Go-back-n ARQ, Point to Point Protocol on Internet ([1] Chapter 10-11).			15	CO2
3	Multiple Access Protocol and Networks: CSMA/CD Protocols; Ethernet LANS; Connecting LAN and Back-Bone Networks-			15	CO3

	Repeaters, Hubs, Switches, Bridges, Router and Gateways([1] Chapter 12). Networks Layer Functions and Protocols: Routing, Routing Algorithms: Distance Vector, Shortest Path Routing Algorithm, Network Layer Protocols: IP protocol, Internet Control Message Protocol, IGMP, ARP, RARP([1] Chapter 19-22).		
4	Transport Layer Functions and Protocols: Transport services- Error control and Flow Control, Reliability, TCP and UDP, Connection Establishment and Release: Three way Handshaking, Concept of Socket and Ports ([1] Chapter 23-24). Application layer Protocol: Overview of WWW, URL, HTTP, SMTP, FTP, POP, TELNET. Domain Name System, Domain Name Servers, DNS Space ([1] Chapter 25-28).	15	CO4

Suggested Readings

1. B. A. Forouzan: Data Communications and Networking, Fourth edition, THM, 2007.
2. Computer Network and Internet by Douglas E Comer.
3. A. S. Tanenbaum: Computer Networks, Fourth edition, PHI, 2002.
4. William Stallings, “Data and Computer Communication”, Prentice Hall.

Online Resources

1. <https://nptel.ac.in/courses/106105183>
2. <https://nptel.ac.in/courses/106106091>

PO-PSO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	1	1	1				1	1			1		1	1
CO 2	1	1	1			1	1	1			1		1	1
CO 3	1	1	1			1	1	2			2		1	1
CO 4	1	1	1			2	1	2			2		1	1

Program	B.Sc. (Hons./ Hons. with Research)				
Year	1	Semester	1		
Course Name	Calculus				
Code	NBSM3103				
Course Type		L	T	P	Credit
Pre-Requisite	10+2 Mathematics	3	1	-	4
Course Objectives	The objective of the course is to provide the concept of limit, continuity and differentiability and to apply the knowledge to solve problems.				
Course Outcomes					
CO1	To understand continuity and differentiability in terms of limits and graphs of certain functions.				
CO2	To understand the consequences of various mean value theorems for differentiable functions.				
CO3	To understand the concepts of asymptotes and inflexion points in curve tracing.				
CO4	To be able to compute the reduction formulae of standard transcendental functions with applications.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	$\varepsilon - \delta$ definition of a limit, Infinite limits, Continuity and types of discontinuities ([1] Chapter 2); Differentiability of a function ([1] Chapter 3), Successive differentiation: Calculation of the nth derivatives, Leibnitz theorem ([1] Chapter 5). Partial differentiation, Euler's theorem on homogeneous functions ([1] Chapter 12).	15	CO1
2	Rolle's theorem, Mean value theorems, Taylor's and Maclaurin's series expansions of one variable ([1] Chapter 7). Indeterminate forms ([1] Chapter 16).	15	CO2
3	Asymptotes ([1] Chapter 9), Curvature, Concavity and inflexion points ([1] Chapter 10), Singular points, Tangents at the origin and nature of singular points, Curve tracing ([1] Chapter 11).	15	CO3
4	Integration of irrational algebraic functions and transcendental functions, Reduction formulae for $\int \sin^n x dx$, $\int \cos^n x dx$, $\int \sin^m x \cos^n x dx$, $\int x^n \sin mx dx$, $\int x^n \cos mx dx$ and $\int x^n (\log x)^m dx$ ([2] Chapter 3&4). Definite integral as a limit of sum ([2] Chapter 5),	15	CO4

Suggested Readings

1. Prasad, Gorakh (2016). Differential Calculus (19th ed.). Pothishala Pvt. Ltd. Allahabad.
2. Prasad, Gorakh (2015). Integral Calculus. Pothishala Pvt. Ltd. Allahabad.

Online Resources

1. <https://archive.nptel.ac.in/courses/111/106/111106146/>

2. <https://vidymitra.inflibnet.ac.in/index.php/search?subject%5B%5D=&course%5B%5D=C+alculus&domain%5B%5D=Physical+%26+Basic+Sciences>

Course Articulation Matrix														
PO- PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	2	1	1				2			1		2	1
CO2	2	2	2	1				2			2		2	2
CO3	1	2	1	1				1			1		1	1
CO4	1	1	2	1				2					1	1

Program	B.Sc. (Hons./ Hons. with Research)				
Year	1	Semester	2		
Course Name	Ordinary Differential Equations				
Code	NBSM3202				
Course Type		L	T	P	Credit
Pre-Requisite	10+2 Mathematics	3	1	-	4
Course Objectives	The objective of this course is to introduce the students to understand and solve of Differential Equations, create various Mathematical models and their applications in everyday life.				
Course Outcomes					
CO1	To understand the genesis of ordinary differential equations of first order and first degree.				
CO2	To learn various techniques of getting exact solutions of linear differential equations of Second and higher order.				
CO3	To develop the concept of a general solution of a linear differential equation of an arbitrary order and also learn a few methods to obtain the general solution of such equations.				
CO4	To formulate mathematical models in the form of ordinary differential equations to suggest possible solutions of the day to day problems arising in physical, chemical and biological disciplines.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Basic concepts and genesis of ordinary differential equations, Order and degree of a differential equation ([2] Chapter 1, Part I), Differential equations of first order and first degree, Equations in which variables are separable, Homogeneous equations, Linear differential equations and equations reducible to linear form, Exact differential equations, Integrating factor ([2] Chapter 2, Part I), First order higher degree equations solvable for x, y and p. Clairaut's form and singular solutions ([2] Chapter 4, Part I).	15	CO1
2	Second Order Linear Differential Equations: Solutions of homogeneous linear ordinary differential equations of second order with constant coefficients ([1] Chapter 2), Euler-Cauchy's linear differential equations, Legendre's linear differential equations. Transformations of the equation by changing the dependent/independent variable, Method of variation of parameters ([2] Chapter 10, Part I), Reduction of order ([1] Chapter 2). Higher Order Linear Differential Equations: Linearly dependent and linearly independent solutions on an interval, Wronskian and its properties.	15	CO2
3	Power series method ([2] Chapter 7, Part II), Frobenius method ([2] Chapter 8, Part II), Legendre's equation, Legendre polynomials, Rodrigue's formula, Orthogonality of Legendre polynomials ([2] Chapter 9, Part II), Bessel's equation, Bessel	15	CO3

	functions and their properties, Recurrence relations ([2] Chapter 11, Part II).		
4	Application of first order differential equations to acceleration-velocity model ([5] Chapter 2), Growth and Decay model ([4] Chapter 2). Introduction to compartmental models ([4] Chapter 2), Lake pollution model (with case study of Lake Burley Griffin) ([4] Chapter 2), Drug Assimilation models ([4] Chapter 2), population models (with limited growth, exponential growth) Epidemic models ([5] Chapter 2 or [4] Chapter 3).	15	CO4

Suggested Readings

1. Erwin Kreyszig (2011). Advanced Engineering Mathematics (10th edition). Wiley.
2. M. D. Raisinghania, Advanced Differential Equations, Eighteenth Edition 2013, S. Chand.
3. H. I. Freedman (1980). Deterministic Mathematical Models in Population Ecology. Marcel Dekker Inc.
4. Barnes, Belinda & Fulford, Glenn R. (2015). Mathematical Modelling with Case Studies, Using Maple and MATLAB (3rd ed.). CRC Press, Taylor & Francis Group.
5. Edwards, C. Henry, Penney, David E., & Calvis, David T. (2015). Differential Equation and Boundary Value Problems: Computing and Modeling (5th ed.). Pearson Education

Online Resources

1. <https://archive.nptel.ac.in/courses/111/106/111106100/>

Course Articulation Matrix														
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	2	1		2			1					1	2
CO2	1	2	2		3			3					2	3
CO3	2	2	1		2			1					2	2
CO4	2	3	2	1	3			2					3	3

Program					
Year	First	Semester			First
Course Name	Business Environment				
Code	NBBA5102				
Course Type		L	T	P	Credit
Pre-Requisite	10+2 in any discipline	4	0	0	4
Course Objectives	To Familiarize students with: Various external and internal factors that impact business and understand the economic, cultural, legal and political issues associated with national and international business.				
Course Outcomes					
CO1	Explain the types of business environment viz Political, Economic, Socio-cultural, Legal, Technological and Global environment.				
CO2	Analyse the existence of business under various Policies Framework laid by legal environment.				
CO3	Examine the role of public sector along with various government regulatory acts and policies regarding business environment including industrial, monetary and fiscal policies.				
CO4	Analyse and evaluate global business environment in terms of Global Trade Policies by respective Institutions along with determining the impact and prospects of Technology in shaping Business.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Module I: Introduction Business Environment: Nature, dimensions and meaning. Components of business environment: economic, political, technological and social environment. Consumerism and consumer protection in India. A brief study of capitalism, socialism and mixed economy.	15	1
2	Module II: Industrial and Legal Environment Industrial Growth and policy, industrial licensing policy. MRTP. Economic planning: aims, objectives and framework of development planning in India. Legal Environment. India's Fiscal and Monetary Policies.	15	2
3	Module III: Public Sector and Economic Organizations Public Sector: Concept, Rationale, Government Programme, Role of Public Sector in India. Foreign Trade	15	3

	Policies. Development Banks: IFCI, IDBI, SIDBI, IIBI.		
4	Module IV: Recent Economic Trends Recent Economic Trends Economic Liberalization, Privatization and Globalization. Foreign investment policy. Export Promotion councils and boards. Import Control. EXIM policy, FEMA, IPR (International and Indian Patent Rights Acts). Anti-Pollution Act. Environmental Groups and Bodies. Euro I, II and III Norms, Introduction to Goods and Services Tax.	15	4

Suggested Readings

1. Mishra S. K. And Puri V. K., Economic Environment of Business, Himalaya Publication.
2. Paul, Justin., Business Environment Text and Cases, Tata McGraw Hill.
3. Shaikh and Saleem, Business Environment, Pearson, 1st Edition.

Online Resources

1. eGyanKosh: Business Environment online available at <https://egyankosh.ac.in/handle/123456789/2898>
2. NPTEL: Introduction to Business environment available at https://onlinecourses.swayam2.ac.in/imb22_mg02/preview

Course Articulation Matrix														
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1									2	2	2
CO2	3	2	2	1	2							2	2	2
CO3	3	3	3	3	3	1	2			1		3	3	2
CO4	1	1	1	2	2	2	2	1				3	3	2

Program					
Year	First	Semester		Second	
Course Name	Business Organisation				
Code	NBBA5203				
Course Type		L	T	P	Credit
Pre-Requisite	10+2 from any discipline	3	1	0	4
Course Objectives	To familiarize students with: Management and business concepts and practices. Emerging challenges of managing resources, managing business processes and managing managers.				
Course Outcomes					
CO1	Understand the concept of business organization and principles of organization.				
CO2	Examine the role of sole proprietorship, Partnership firm, joint stock concerns and companies.				
CO3	Analyse the sources and methods of Business Finance and analyse working of financial institutions like IFCI, SFC, ICICI, IDBI and security market.				
CO4	Assessing market structure and applying it to different industries to understand the four P's of marketing structure of these industries. Applying the concepts of advertisement and sales promotion to real life situations.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Module I: Introduction to Organization Concepts and objectives of business organization, establishment of a new business, pre-establishment considerations and social responsibility of business. Meaning, objective and principles of organization, line and staff, functional organization, concept of scalar chain.	15	1
2	Module II: Forms of Business Organization Sole Proprietorship: Meaning, characteristics and legal requirements. Partnership firms: Meaning, partnership deed and legal requirements as per Partnership Act 1932. Joint stock concerns: Meaning, features, kinds of companies, legal requirements as per Companies Act 2013.	15	2
3	Module III: Business Finance Business Finance: Concept, need and significance. Methods of financing: long term, medium term and short term. National finance and international finance. Financial institutions: Brief introduction to IFCI, SFC, ICICI, IDBI. Security market: An introduction to primary and secondary market.	15	3
4	Module IV: Marketing	15	4

	Marketing: Concept of marketing, four P's of Marketing. Distribution channel: Meaning, importance, and significance of middlemen. Advertisement and sales promotion: Meaning and objectives. Introduction to Consumer Behaviour.		
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Suggested Readings

1. Tulsian P. C. and Pandey V., Business Organization and Management, Pearson Education.
2. Bhushan Y. K., Fundamentals of Business Organization and Management, Sultan Chand and Sons.
3. Chhabra T.N., Business Organisation, Dhanpat Rai and Sons.
4. Robert., Modern Business Administration, McMillan India.

Online Resources

1. SWAYAM: Business Organization and Management online available at https://onlinecourses.swayam2.ac.in/nou21_mg03/preview
2. eGyanKosh: Business Organisation online available at <https://egyankosh.ac.in/handle/123456789/3592>

Course Articulation Matrix														
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	1	1				1	1	1			2	2	1
CO2	3	1	2	1	2							2	2	1
CO3	3	3	3	3	3	1	2					3	3	1
CO4	1	1	1	2	2	2	2	1				3	3	1

Program	For all UG Programs				
Year	1	Semester		1	
Course Name	Descriptive Statistics				
Code	NBSE1101				
Course Type	GE	L	T	P	Credit
Pre-Requisite	10+2 in any discipline	3	1	0	4
Course Objectives	<p>The general objectives of the course are to:</p> <p>Understand Statistics, its scope and importance in various fields.</p> <p>Learn difference between sample population data and its types.</p> <p>Understand graphical representation of different types of data.</p> <p>Differentiate between measures of central tendency & dispersion.</p>				
Course Outcomes:					
CO1	To understand concept of sample vs. population and difference between different types of data.				
CO2	To be able to apply different methods for summarising data sets, Interpret histograms and ogives etc.				
CO3	To describe data with measures of central tendency and measures of dispersion.				
CO4	To understand measures of skewness, kurtosis and their utility.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Concept of statistical population, Attributes and variables (discrete and Continuous) ([2] Chapter 1); Primary data – designing a questionnaire and schedule, collection of primary data, Secondary data ([2] Chapter 3); Presentation of data: classification, tabulation ([2] Chapter 5).	15	CO1
2	Diagrammatic & graphical representation of grouped data. Frequency distributions, cumulative frequency distributions and their graphical representations, histogram, frequency polygon and ogives ([3] Chapter 3).	15	CO2
3	Measure of central tendency: Average or arithmetic mean, median, mode, geometric mean & harmonic mean for grouped and ungrouped data with their merits and demerits ([3] Chapter 4).	15	CO 3
4	Dispersion, merits and demerits of these measures ([1] Chapter 7); Moments, Shephard's correction for moments ([2] Chapter 9); Skewness and Kurtosis and their Measures ([1] Chapter 8); Measures based on quartiles (Quartiles, Deciles and percentiles) ([1] Chapter 7).	15	CO4

Suggested Readings

1. Beri, G.C. (2011). Business Statistics (3rd ed.), TMH Education Pvt. Ltd. New Delhi.
2. Gupta, S.P. (2011). Statistical Methods (41st ed.), Sultan Chand and Sons New Delhi.

3. Tulsian, P.C. and Tulsian, Bharat. (2019). Business Statistics (2nd ed.), Sultan Chand and Company Ltd. New Delhi.

Online Resources

1. <https://heecontent.upsdc.gov.in/Home.aspx>
2. <https://www.edx.org/search?q=statistics>

Course Articulation Matrix														
PO- PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1			1	1	1					1	1
CO2	1	1	1			2		1					1	1
CO3	1	1	1			2		1					1	1
CO4	1	1	1			2		1					1	1

Program	For all UG Programs				
Year	1	Semester		2	
Course Name	Probability & Distributions				
Code	NBSE1201				
Course Type	GE	L	T	P	Credit
Pre-Requisite	10+2 in any discipline	3	1	0	4
Course Objectives	<p>The general objectives of the course are to:</p> <ul style="list-style-type: none"> understand concept of probability along with basic laws and axioms of probability. understand Addition & Multiplication theorems of probability. understand the concept of random variable (discrete and continuous), concept of probability distribution. knowledge of discrete & continuous distributions. 				
Course Outcomes:					
CO1	To apply the concept of different terms used in probability.				
CO2	To apply basic probability principles to solve real life problems.				
CO3	To differentiate & apply different types of distributions.				
CO4	To understand applications of discrete & continuous distributions to solve the problems.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Basic Concepts of probability, Random Experiment, Trial, Sample Point, Sample space, events, Definitions of Mutually Exclusive, Exhaustive and Equally Likely events, Definitions of Probability: Classical, relative frequency and axiomatic approaches and their limitations ([2] Vol. 2, Chapter 1).	15	CO1
2	Theorems on Probability: Addition theorem of Probability for n Events, Theorem of Total Probability for n Events, Conditional Probability, Multiplication Theorem of Probability for n events, Independent Events. Bayes' Theorem and its Applications ([2] Vol. 2, Chapter 1).	15	CO2
3	Random variables – discrete and continuous, ([1], Chapter 10); probability mass function (pmf) and probability density function (pdf), Cumulative distribution function (cdf), Joint distribution of two random variables, marginal and conditional distributions, Independence of random variables ([3], Chapter 5); Expectation of a random variable and its properties, expectation of sum of random variables and product of independent random variables ([3], Chapter 6).	15	CO 3
4	Probability Distributions: Binomial, Poisson, Normal distribution and their properties ([1], Chapter 10).	15	CO4

Suggested Readings

1. Beri, G.C. (2011). Business Statistics (3rd ed.), TMH Education Pvt. Ltd. New Delhi.
2. Gupta, S.P. (2011). Statistical Methods (41st ed.), Sultan Chand and Sons New Delhi.
3. Gupta, S.C. and Kapoor, V.K. (2000). Fundamentals of Mathematical Statistics (10th ed.), Sultan Chand and Sons, New Delhi.

Online Resources

1. <https://www.coursera.org/search?query=statistics&>
2. <https://www.edx.org/search?q=statistics>

Course Articulation Matrix														
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1			1		1					1	1
CO2	1	2	1			1		1					1	1
CO3	1	2	2			2		1					1	1
CO4	1	2	2			2		1					1	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	2	Semester	III		
Course Name	Java Programming				
Code	NBSC3301				
Course Type	DSC7	L	T	P	Credit
Pre-Requisite	Basic Concept of Computer Languages.	3	1	-	3
Course Objectives	To understand the basic concepts and fundamentals of platform independent object-oriented language and implementing the Polymorphism, Abstraction and Inheritance using JAVA Programming.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Get the knowledge of the structure and model of the Java programming language,				
CO2	Use the Java programming language for various programming technologies				
CO3	Develop software in the Java programming language				
CO4	Evaluate user requirements for software functionality required to decide whether the Java programming language can meet user requirements				
Module	Course Contents	Contact Hrs.		Mapped CO	
1	Introduction to Java: Java Architecture and Features, Semantic and Syntax, differences between C++ and Java, Compiling and Executing a Java Program, Variables, Constants, Keywords Data Types ([1] Chapter 3). Operators: Arithmetic, Logical and Bitwise and Expressions, Comments, Doing Basic Program Output ([1] Chapter 4). Decision Making Constructs: Conditional Statements and Loops and Nesting ([1] Chapter 5). Java Methods: Defining, Scope, Passing and Returning Arguments, Type Conversion and Type Checking ([1] Chapter 7).	15		1	
2	Arrays, Strings, I/O and Object-Oriented Programming: Creating & Using single & Multi-dimensional Arrays, Referencing Arrays. Strings: The Java String class, Creating & Using String Objects, Manipulating Strings, String	15		2	

	<p>Immutability & Equality, Passing Strings to & from Methods. String Buffer Classes: Simple I/O using Scanner class, Byte and Character streams, Reading/Writing from Console and Files. Principles of Object-Oriented Programming, Defining & Using Classes, Controlling Access to Class Members, Class Constructors, Method Overloading, Class Variables & Methods, Objects as parameters, Final Classes, Object class ([1] Chapter 13).</p>		
3	<p>Inheritance, Interfaces, Packages and Exceptionhandling: Inheritance: Single Level and Multilevel, Method Overriding, Dynamic Method Dispatch, Abstract Classes, Interfaces and Packages, Package and Class Visibility, Using Standard Java Packages: util, lang, io, net ([1] Chapter 9). WrapperClasses, Autoboxing/Unboxing, Enumerations and Metadata.Exception types, Uncaught Exceptions, Throw, Built-in Exceptions, Creating your own Exceptions ([1] Chapter 10).</p>	15	3
4	<p>Multi-Threading, Networking Basics and Database Connectivity, Applets and Event Handling: Multi-threading, creating single and multiple Threads, Thread prioritization, Suspending/resuming threads ([1] Chapter 11). Accessing and manipulating Databases using JDBC. Java Applets: Introduction to Applets, Writing Java Applets. Event Handling Mechanisms, Listener Interfaces. Introduction to AWT controls, Swing, Overview of servlets ([1] Chapter 23).</p>	15	4

Suggested Readings

1. Herbert Schildt, "Java: The Complete Reference", Seventh Edition.
2. Ken Arnold, James Gosling, David Homes, "The Java Programming Language", 4th Edition, 2005.
3. James Gosling, Bill Joy, Guy L Steele Jr, Gilad Bracha, Alex Buckley "The Java Language Specification, Java SE 8 Edition (Java Series)", Published by Addison Wesley, 2014.

Online Resources

- 1) <https://archive.nptel.ac.in/courses/106/105/106105191/>
- 2) <https://www.digimat.in/nptel/courses/video/106105191/L01.html>

PO- PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1			1							1	1
CO2	1	1	1		1	1							1	
CO3	1		1	1	1	1		1	1				1	1
CO4	1			1	1	1		1	1	1	1		1	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science					
Year	2	Semester			III	
Course Name	Java Programming LAB					
Code	NBSC3351					
Course Type	DSC7	L	T	P	Credit	
Pre-Requisite	Basic Concept of Computer Languages.	-	-	2	1	
Course Objectives	To understand the basic concepts and fundamentals of platform independent object-oriented language and implement the Class, Objects, Polymorphism, Abstraction and Inheritance using JAVA Programming.					
Course Outcomes: Upon successful completion of syllabus, a student will be able to:						
CO1	Write basic programs using data types, operators, class and objects.					
CO2	Develop programs using OOPs concepts like abstraction, polymorphism and inheritance.					
CO3	Develop software in the Java programming language					
CO4	Develop software on applets, servlets, Swing and connecting to database					

1. To find the sum of any number of Integers entered as Command line arguments.
2. To find the Factorial of a given number.
3. To learn use of Single Dimensional Array by defining the Array dynamically.
4. To learn use of length in case of a two dimensional Array.
5. To convert a Decimal to Binary number.
6. To check if a number is Prime or not, by taking the number as input from the keyboard.
7. To find the sum of any number of Integers interactively, i.e. entering every number from the keyboard, whereas the total number of Integers is given as a command line argument.
8. Write a program that show working of different functions of String and StringBuffer classes like setCharAt(), setLength(), append(), insert(), concat() and equals().
9. Write a program to create a distance Class with methods where distance is computed in terms of feet's and inches, how to create objects of a Class and to see the use of this Pointer.
10. Modify the distance class by creating Constructor for assigning values (feet and inches) to the distance object. Create another object and assign second object as reference variable to another object reference variable. Further create a third object which is a clone of the first object.

11. Write a program to show that during function overloading, if no matching argument is found, then java will apply automatic type conversions(from lower to higher data type).
12. Write a program to show the difference between public and private access specifiers. The program should also show that primitive data types are passed by value and objects are passed by reference and to learn use of final keyword.
13. Write a program to show the use of Static functions and to pass variable length arguments in a function.
14. Write a program to demonstrate the concept of Boxing and Unboxing.
15. Create a multi-file program where in one file a string message is taken as input from the user and the function to display the message on the screen is given in another file (make use of Scanner package in this program).
16. Write a program to create a Multilevel Package and also creates a reusable class to generate Fibonacci series, where the function to generate Fibonacci series is given in a different file belonging to the same package.
17. Write a program that creates illustrates different levels of protection in classes/subclasses belonging to same package or different packages.
18. Write a program Divide byZero that takes two numbers a and b as input, computes a/b, and invokes Arithmetic Exception to generate a message when the denominator is zero.
19. Write a program to show the use of nested try statements that emphasizes the sequence of checking for catch handler statements.
20. Write a program to create your own exception types to handle situation specific to your application (Hint: Define a subclass of Exception which itself is a subclass of throwable).
21. Write a program to demonstrate priorities among Multiple Threads.
22. Write a program to demonstrate Multithread communication by implementing synchronization among threads (Hint: you can implement a simple producer and consumer problem).
23. Write a program to create URL object, create a URLConnection using the openConnection() method and then use it examine the different components of the URL and content.
24. Write a program to implement a simple datagram client and server in which a message that is typed into the server window is sent to the client side where it is displayed.
25. Write a program that creates a Banner and then creates a thread to scrolls the message in the banner from left to right across the applet's window.

Online Resources

- 1) <https://archive.nptel.ac.in/courses/106/105/106105191/>
- 2) <https://www.digimat.in/nptel/courses/video/106105191/L01.html>

PO- PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1		2	3	3	3		3	2	1	3		3	1
CO2	1	1	2		2	3		3	2	1	3		1	1
CO3	1		2	2	2	3		3	2	1	3		3	1
CO4	1			2	2	2		3	2	1	3		1	1

Program	B.Sc. (Hons./ Hons. with Research) Computer Science				
Year	2	Semester		III	
Course Name	Discrete Structures				
Code	NBSC3302				
Course Type	DSC8	L	T	P	Credit
Pre-Requisite	Basic knowledge of Mathematics	3	1		4
Course Objectives	The objectives of the course are to understand and apply the fundamental concepts in discrete structure.				
Course Outcomes: After completion of the course, students shall be able to					
CO1	Understand the notion of mathematical thinking, mathematical proofs and be able to apply the problem solving.				
CO2	Understand the concepts of recurrence relation and generating function.				
CO3	Acquire the basic ideas of graphs and tree.				
CO4	Understand the concepts of mathematical logic for analyzing propositions and proving theorems.				

Module	Course Contents	Contact Hrs.	Mapped CO
1	Sets - finite and infinite sets, uncountably infinite sets, functions, relations, operations on relation, composite relations, equality of relations, properties of binary relations, closure, partial ordering relations ([1] Chapter 2). Counting-Pigeonhole principle, mathematical induction ([1] Chapter 5 and 6).	15	CO1
2	Recurrence Relation & Generating function: recurrence relations, linear recurrence relations with constant coefficients and their solution, numeric function, generating functions, solution of recurrence relation by method of generating functions ([1] Chapter 8).	15	CO2
3	Basic terminology, models and types, multi-graphs and weighted graphs, graph representation, graph isomorphism, graph homomorphism, Euler and Hamiltonian paths and circuits, planar graphs, bipartite graph, definition of trees, tree traversal, binary search tree ([1], Chapter 10 and 11).	15	CO3

4	Propositional Logic:Propositions, Well-formed formulas, tautologies, satisfiability, contradiction, algebra of proposition, theory of inference ([2] Chapter 1).	15	CO4
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Suggested Readings

1. Kenneth Rosen, Discrete Mathematics and Its Applications, Sixth Edition, McGraw Hill 2006.
2. J. P. Tremblay and R Manohar, Discrete Mathematical structure with Application to computer Science. Tata McGraw Hill.
3. NarsinghDeo, *Graph Theory with Applications to Engineering and Computer Science*, Prentice Hall.

Online Resources

1. <https://archive.nptel.ac.in/courses/106/105/106105192/>
2. <http://acl.digimat.in/nptel/courses/video/106105192/L46.html>

PO- PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1					1					1	2
CO2	1	2	2		2			2					2	2
CO3	1	2	1		1			1					2	1
CO4	1	1	2		2			2					2	2

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	2	Semester	III		
Course Name	Design and Analysis of Algorithms				
Code	NBSC3303				
Course Type	DSC9	L	T	P	Credit
Pre-Requisite	Concept of Data Structure	3	1	-	4
Course Objectives	Analyze the asymptotic performance of algorithms. Write rigorous correctness proofs for algorithms. Demonstrate a familiarity with major algorithms and data structures. To develop the ability to analyze the running time and prove the correctness of basic algorithms				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Learn good principles of Algorithm Design.				
CO2	Learn how to Analyze Algorithms and estimate their Worst-Case and Average- Case behavior (in easy cases).				
CO3	Become familiar with fundamental Data Structures and with the manner in which these Data Structures can best be implemented become accustomed to the description of Algorithms in both functional and Procedural Styles.				
CO4	Learn how to apply their Theoretical Knowledge in practice (via the Practical component of the course).				
Module	Course Contents	Contact Hrs.	Mapped CO		
1	Introduction: Algorithm Definition and Characteristics, Design and Analysis, Time and space complexity of an algorithm, Asymptotic notation. Growth of Functions ([1] Chapter 1). Basic Algorithm Design Techniques: Divide-and-conquer, Greedy approach, Randomization and dynamic programming. ([1] Chapter 3). Backtracking: n-Queens problem, Traveling Salesman Problem ([1] Chapter 25).	15	1		
2	Advanced Data Structures: Binary Search Tree, B – trees, Binomial Heaps, Fibonacci Heaps,	15	2		

	Searching and Sorting: Internal and External, Elementary Sorting techniques: Bubble Sort, Insertion Sort, Merge Sort, ([1] Chapter 4) Advanced Sorting techniques: Heap Sort, Quick Sort. Sorting in Linear Time: Bucket Sort, Radix Sort and Count Sort, ([1] Chapter 8) Searching Techniques: Linear Search, Binary Search.([1] Chapter 12).		
3	Greedy methods: Knapsack0/1, Fractional Knapsack, Minimum Spanning trees – Prim’s and Kruskal’s algorithms, Single source shortest paths - Dijkstra’s and Bellman Ford algorithms. Dynamic programming: All pair shortest paths: Warshal’s and Floyd’s algorithms, Resource allocation problem, ([1] Chapter 26).	15	3
4	Advanced Data Structures: String Matching: String Matching Algorithms: Naïve, Rabin Karp, Knuth-Morris-Pratt, ([1] Chapter 36). NP-completeness: Definition of class NP, P, NP-hard and NP-complete problems, Graph Coloring. ([1] Chapter 18-19) String	15	4

Suggested Readings

1. Udit Agarwal, Algorithms Design and Analysis, Dhanpat Rai & Co.
2. Thomas H Cormen, Charles E Lieserson, Ronald L Rivest and Clifford Stein, Introduction to Algorithms, Second Edition, MIT Press/McGraw-Hill, 2001.
3. Jon Kleinberg and Éva Tardos, Algorithm Design, Pearson, 2005.

Online Resources

- 1) <https://archive.nptel.ac.in/courses/106/106/106106131/>
- 2) <https://archive.nptel.ac.in/courses/106/101/106101060/>

PO- PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2		2	1	2			2					2	2
CO2	1		1	1	2	1		2					1	2
CO3	2		2	2	2			2		1	1		1	2
CO4	2			2	2	1		2	1		2		2	2

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	2	Semester	IV		
Course Name	Database Management System				
Code	NBSC3401				
Course Type	DSC10	L	T	P	Credit
Pre-Requisite	Fundamental computer knowledge that includes concepts of computer architecture, storage and hardware	3	1	-	3
Course Objectives	Introduce fundamental concepts, terminology and application of databases, design concepts and creation of relational databases basic To Provide overview of transaction management, database recovery and security.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Gain knowledge of Database systems and Database Management Systems software.				
CO2	Model data in applications using Conceptual Modeling tools such as ER Diagrams and Design Database schemas based on the model.				
CO3	Demonstrate an understanding of Normalization theory and apply such knowledge to the normalization of a database.				
CO4	Compare, Contrast and Analyze the various emerging technologies for Database systems such as MySQL.				
Module	Course Contents	Contact Hrs.	Mapped CO		
1	Introduction to DBMS: Introduction to Traditional File Oriented System, Disadvantages of File Oriented System, an Overview of the DBMS. Concept of Database System, Advantages of DBMS over the File Oriented System, Components of DBMS, Database Administrator and Database Users, Structure of DBMS, Data Independence, Data Abstraction, Three Level Architecture of Database System. Introduction to Data Models: Hierarchical, Network and Relational Model, OOP's Model, Comparison of Network,	15	1		

	Hierarchical and Relational Model. OOP's Model Database Languages: DML, DDL, DCL, TCL and Interfaces ([1] Chapter 1).		
2	Relational and E-R model: Relational Data Model: Relational Database, Codd's Rules Relational Algebra. E-R Modeling: Entity set, Entity Types: Strong and Weak entities, Attribute and Keys Concept, Entity Integrity and Referential Integrity, Relationships types, Roles and Structural Constraints. Data Modeling Using the Entity-Relationship Model, Concepts, Notation for ER Diagram, Mapping Constraints, Keys, Aggregation, Specialization and Generalization, ([1] Chapter 6).	15	2
3	Introduction to SQL Queries: Structured Query Language, SQL Data Types, Basic SQL Query, Nested Queries, JOIN, Aggregate Operators, Null Values, Basic Retrieval Capability, Insert, Update Commands, DDL, DML, Views ([1] Chapter 3). Data Normalization: Functional Dependencies, Armstrong Rules, Closure of Attributes, Normal Form up to 3rd Normal Form, BCNF, Join Dependencies, Decompositions([1] Chapter 7).	15	3
4	Database Protection & Distributed Database: Transaction Processing Concepts, Introduction to Transaction Processing, Transaction States and State Diagram, Transaction and System Concepts, Desirable Properties of Transactions, Schedules and Recoverability, Serializability of Schedules, ([1] Chapter 17). Locking Techniques for Concurrency Control, Concurrency Control Based on Timestamp Ordering, Multi-Version Concurrency Control Techniques ([1] Chapter 18).	15	4

Suggested Readings

1. Abraham Silberschatz, Henry Korth, S. Sudarshan, "Database Systems Concepts", 4th Edition, McGraw Hill, 1997.
2. Bipin Desai, "An Introduction to database Systems", Galgotia Publications, 1991.
3. Date, "Database Management Systems", Pearson Education Asia.

Online Resources

1. <https://archive.nptel.ac.in/courses/106/105/106105175/>
2. <https://nptel.ac.in/courses/106106220>

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1		1									2	
CO2	2		2	1	1			1	2				2	
CO3	2	1	2	2	1								2	2
CO4	1				2	1		2			1			2

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	2	Semester	IV		
Course Name	Database Management System LAB				
Code	NBSC3451				
Course Type	DSC10	L	T	P	Credit
Pre-Requisite	Fundamental computer knowledge that includes concepts of computer architecture, storage and hardware			2	1
Course Objectives	Introduce fundamental concepts, terminology and application of databases, design concepts and creation of relational databases basic To Provide overview of transaction management, database recovery and security.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Create database schema, table and performing various modifications of table structure.				
CO2	Perform various kinds of DML operations on table.				
CO3	Decompose and joining of tables on the basis of Normalization process.				
CO4	Perform nested queries on tables and creating views.				

1. Create the following tables:

l) client_master

Column_name	Datatype
client_no	varchar2
Name	varchar2
address1	varchar2
City	varchar2
State	varchar2
Pincode	NUMBER
bal_due	NUMBER

II)Product_master

Column_name	Datatype
Product_no	varchar2
Description	varchar2
Profit_percen	NUMBER
Unit_measure	varchar2
Qty_on_hand	NUMBER
Sell_pric	NUMBER
Cost_price	NUMBER

2 Insert the following data into their respective tables:

i) Insert at least 6 rows in table client_master

client_no	Name	Address1	City	State	Pincode	Bal_due
001	IVAN		NAGPUR	Maharashtra	400054	15000
002	VANDANA		CHENNAI	Tamilnadu	780001	0
003	PRANAV		NAGPUR	Maharashtra	400057	5000
004	BASU		NAGPUR	Maharashtra	400056	0
005	RAVI		LUCKNOW	UP	226025	2000
006	ARTI		LUCKNOW	UP	226001	0

ii) Insert at least 10 rows in table Product_master.

Product_no	Description	Profit_perce n	Unit_measur e	Qty_on_han d	Sell_pri c	Cost_pric e
P07865	1.22 floppies	5	piece	100	5	500
P00001	1.44 floppies	5	Piece	100	525	50
P08865	1.22 Drive	5	Piece	2	1050	1000
P07975	1.44 Drive	5	Piece	10	1050	1000
P07965	540 HDD	4	Piece	10	8400	8000
P03453	Monitors	6	Piece	1	12000	1120

3: On the basis of above two tables answer the following Queries:

- i) Find out the names of all the clients.
- ii) Retrieve the list of names and cities of all the clients.
- iii) List the various products available from the productmaster table.
- iv) List all the clients who are located in Bombay.
- v) Display the information for client no 0001 and 0002.
- vi) Find the products with description as '1.44 drive' and '1.22 Drive'.
- vii) Find all the products whose sell price is greater than 5000.
- viii) Find the list of all clients who stay in in city 'Nagpur' or city 'Delhi' or 'Chennai'.
- ix) Find the product whose selling price is greater than 2000 and less than or equal to 5000.
- x) List the name, city and state of clients not in the state of 'Maharashtra'.

Q4.To manipulate the Operations on the table.

Using the table client master and product master answer the following:

- (a) Change the selling price of '1.44 floppy drive to Rs.1150.00.
- (b) Delete the record with client 0001 from the client master table.
- (c) Change the city of client_no'0005' to Mumbai.
- (d) Change the bal_due of client_no 0001, to 1000.
- (e) Find the products whose selling price is more than 1500 and also find the new selling price as original selling price *15.
- (f) Find out the clients who stay in a city whose second letter is a.
- (g) Find out the name of all clients having 'a' as the second letter in their names.
- (h) List the products in sorted order of their description.
- (i) Count the total number of orders x.
- (j) Calculate the average price of all the products.
- (k) Calculate the minimum price of products.
- (l) Determine the maximum and minimum prices
- (m) Rename the title as max_price and min_price respectively.
- (n) Count the number of products having price greater than or equal to 1500.

5. To implement and manipulate the structure of the table. Write SQL Queries to perform following operations.

- (a) To change the name of any existing table.
- (b) To change the name of column.
- (c) To drop a column from the current table.
- (d) To decrease the cardinality of a table if table data exist.
- (e) To add a new column to the existing tables.
- (f) To Drop a table from the database.
- (g) To change the data type of any column.
- (h) To Add Primary key constraint.
- (i) To Add Foreign key constraint.
- (j) To Drop Primary key constraint.

(k) To Drop Foreign key constraint.

6. (a) To implement the concept of joins.

- i. Write Sql queries to implement or Joint Multiple Table (Equi Join).
- ii. Write Sql queries to implement Natural Join.
- iii. Write Sql queries to implement Cartesian product.
- iv. Write Sql queries to implement INNER JOIN.
- v. Write Sql queries to implement LEFT OUTER JOIN.
- vi. Write Sql queries to implement RIGHT OUTER JOIN.
- vii. Write Sql queries to implement FULL OUTER JOIN.

(b) Answer the following Queries

- i. Find out the product which has been sold to 'Ivan Sayross.'
- ii. Find out the product and their quantities that will have do delivered.
- iii. Find the product_no and description of moving products.
- iv. Find out the names of clients who have purchased 'CD DRIVE'
- v. List the product_no and s_order_no of customers having qty ordered less than 5 from the order details table for the product "1.44 floppies".
- vi. Find the products and their quantities for the orders placed by 'VandanSaitwal' and "Ivan Bayross".
- vii. Find the products and their quantities for the orders placed by client_no "C00001" and "C00002".
- viii. Find the order No,, Client No and salesman No. where a client has been received by more than one salesman.
- ix. Display the s_order_date in the format "dd-mm-yy" e.g. "12- feb-96".
- x. Find the date , 15 days after date.

Q7. To implement the concept of grouping of Data.

- (a) Print the description and total quantity sold for each product.
- (b) Find the value of each product sold.
- (c) Calculate the average quantity sold for each client that has a maximum order value of 15000.
- (d) Find out the products which have been sold to Ivan.
- (e) Find the names of clients who have 'CD Drive'.
- (f) Find the products and their quantities for the orders placed by 'Vandana' and 'Ivan'.
- (g) Select product_no, total qty_ordered for each product.
- (h) Select product_no, product description and qty ordered for each product.
- (i) Display the order number and day on which clients placed their order.
- (j) Display the month and Date when the order must be delivered.

Q8. To implement the concept of Sub queries.

- (a) Find the product no and description of non- moving products.
- (b) Find the customer name, address, city and Pincode for the client who has placed order no "019001".
- (c) Find the client names that have placed order before the month of May 96.

- (d) Find out if product “1.44 Drive” is ordered by only client and print the client_no name to whom it was sold.
- (e) Find the names of client who have placed orders worth Rs.10000 or more.
- (f) Select the orders placed by ‘Rahul Desai’.
- (g) Select the names of persons who are in Mr. Pradeep’s department and who have also worked on an inventory control system.
- (h) Select all the clients and the salesman in the city of Nagpur.

Online Resources

1. <https://archive.nptel.ac.in/courses/106/105/106105175/>
2. <https://nptel.ac.in/courses/106106220>

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO 6	PO 7	PO8	PO9	PO10	PO11	PO 12	PS O1	PS O2
CO1	1		2	3	3	3		3	2	1	3		3	1
CO2	1	1	2		2	3		3	2	1	3		1	1
CO3	1		2	2	2	3		3	2	1	3		3	1
CO4	1			2	2	2		3	2	1	3		1	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science					
Year	2	Semester			IV	
Course Name	Programming Concept with Python					
Code	NBSC3402					
Course Type	DSC11	L	T	P	Credit	
Pre-Requisite	Knowledge of Basic Computers	3	1	-	3	
Course Objectives	To provide programming constructs like variables, conditional logic, looping, functions and the concepts of String, List and Tuples etc.					
Course Outcomes: Upon successful completion of syllabus, a student will be able to:						
CO1	Learn the concept and terminology of Python Programing.					
CO2	Develop simple program using Python.					
CO3	Use Python lists, tuples to represent Compound Data.					
CO4	Acquire the concept of File Processing and data visualization.					
Module	Course Contents			Contact Hrs.	Mapped CO	
1	Python Introduction and Setting up the Environment: Introduction to Programming, Setting up Python environment, Python IDEs, Python Interpreter and Interactive Mode, ([3] Chapter 1) Basic Syntax and Data Types: Input/output, Comments, Variables, Data types, Typecasting, Operators: Arithmetic, Assignment, Comparison, Logical, Identity, Membership, Bitwise operators ([3] Chapter 2)			15	1	
2	Strings: Creating, Formatting, Indexing, Slicing, String methods, ([3] Chapter 2). Lists:Creating, Properties, Indexing, Slicing, Methods, Modifying lists, Tuples:Syntax, Properties, Indexing, Slicing, Methods, Sets, Dictionaries, Conditional Statements: if, if-else,else, Loops:while, for, break, continue, pass,			15	2	

	range. ([3] Chapter 4).		
3	Functions:Creating, Calling, Arguments, Variables, Recursion, ([3] Chapter 9). Modules: Importing module, Creating and exploring modules, Math module, Random module, Time module, Packages:Creating, Importing, ([3] Chapter 10). OOPs: Classes & Objects, Inheritance ([3] Chapter 10).	15	3
4	Files: Opening, Reading, Writing, Closing files. Exceptions & Error Handling: Syntax errors, Logical errors, try/except/finally, Plotting Visualization: Subplot, colors markers, line plots, Bar graph, pi-chart, scattered graph, histogram using Matplotlib library. ([3] Chapter 11).	15	4

Suggested Readings

1. Mark Lutz, Learning Python, 5th Edition, O'Reilly
2. Tony Gaddis, Starting Out With Python, 2nd Edition.
3. R. NageswaraRao, Core Python Programming, Dreamtech.

Online Resources

1. <https://archive.nptel.ac.in/courses/106/106/106106182/>
2. <https://nptel.ac.in/courses/106106145>

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2		1					1					2	1
CO2	2		1	2	2			1					1	1
CO3	2		1		1			1						1
CO4	2		1	2	2	1		1						1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	2	Semester		IV	
Course Name	Python Programming LAB				
Code	NBSC3452				
Course Type	DSC11	L	T	P	Credit
Pre-Requisite	Basic Concept of Computer Languages.	-	-	2	1
Course Objectives	To provide programming constructs like variables, conditional logic, looping, functions and the concepts of String, List and Tuples etc.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Develop and execute simple Python Programs.				
CO2	Structure a Python Program into Functions and use of arguments and return values.				
CO3	Use Python lists, tuples to represent Compound Data.				
CO4	Develop Python Programs for File Processing and data visualization.				

1. Write a Python program to do arithmetical operations.
2. Write a Python program to find the area of a triangle.
3. Write a Python program to solve quadratic equation.
4. Write a Python program to swap two variables.
5. Write a Python program to generate a random number.
6. Write a Python program to convert kilometers to miles.
7. Write a Python program to convert Celsius to Fahrenheit.
8. Write a Python program to display calendar.
9. Write a Python Program to check if a Number is Positive, Negative or Zero.
10. Write a Python Program to check if a Number is Odd or Even.
11. Write a Python Program to Check Leap Year.
12. Write a Python Program to Check Prime Number.
13. Write a Python Program to print all Prime Numbers in an Interval.

14. Write a Python Program to Find the Factorial of a Number.
15. Write a Python Program to Display Fibonacci sequence Using Recursion.
16. Write a Python Program to Find Factorial of Number Using Recursion.
17. Write a Python program to print all Prime numbers between 1 and 100.
18. Write a Python program to copy all elements of one Array into another Array.
19. Write a Python program to find the frequency of each element in the Array.
20. Write a Python program to left rotate the elements of an Array.
21. Write a Python program to sort the elements of an Array in Ascending order.
22. Write a Python Program to append element in the list.
23. Write a Python Program to compare two lists.
24. Write a Python Program to create a Dictionary.
25. Write a Python Program to convert list to Dictionary.

Online Resources

1. <https://archive.nptel.ac.in/courses/106/106/106106182/>
2. <https://nptel.ac.in/courses/106106145>

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1		2	3	3	3		3	2	1	3		3	1
CO2	1	1	2		2	3		3	2	1	3		1	1
CO3	1		2	2	2	3		3	2	1	3		3	1
CO4	1			2	2	2		3	2	1	3		1	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	2	Semester	IV		
Course Name	Artificial Intelligence				
Code	NBSC3403				
Course Type	DSC12	L	T	P	Credit
Pre-Requisite	Understanding of computer science fundamentals, particularly in algorithms, data structures	3	1	-	4
Course Objectives	To provide an introduction to the fundamental concepts of Knowledge representation, structured knowledge representation, Game playing and Natural language processing.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Explain what constitutes "Artificial" Intelligence and how to identify systems with Artificial Intelligence.				
CO2	Formalize a given problem in the language/framework of different AI methods (e.g., as a search problem, as a constraint satisfaction problem, as a planning problem, etc.).				
CO3	Design and perform an empirical evaluation of different algorithms on problem formalization, and state the conclusions that the evaluation supports.				
CO4	Explain the limitations of current Artificial Intelligence techniques.				
Module	Course Contents	Contact Hrs.	Mapped CO		
1	Introduction: Historical evolution of AI, Applications of AI, Branches of AI, Agent, Agent function, characteristics of intelligent agents ([1] Chapter 1). Problem Solving Methods: search strategies, Uninformed Search Strategies: Breadth- First Search, Depth-First Search, Depth Limited Search and Iterative Deepening Search ([1] Chapter 2). Informed Search Strategies: BFS, A* Algorithm, Hill-Climbing, Constraint Satisfaction Problem(CSP), Mean-End-Analysis ([1] Chapter 3).	15	1		
2	Knowledge Representation: Representation and Mapping,	15	2		

	([1] Chapter 4). First Order Predicate Logic: Unification, modus ponens, resolution, Forward and backward chaining, Non-monotonic Reasoning, probabilistic reasoning, Probability and Bayes Theorem, Propositional Logic.([1] Chapter 10).		
3	Structured knowledge representation: Semantic nets, Knowledge Acquisition, exceptions and default frames, conceptual dependency, and scripts, ([1] Chapter 12 Natural Language Processing: Introduction, Overview of Linguistics, Grammar and Languages, Semantic Analysis, Natural Language Generation, Natural Language Systems, ([1] Chapter 21).	15	3
4	Game Playing: Overview, Mini-Max, Alpha-Beta Cut-off, Iterative deepening. ([1] Chapter 25). Introduction: Large Language Model, LLM Models, Architecture & Working of LLM, LLM Applications.([1] Chapter 5).	15	4

Suggested Readings

1. Elaine Rich, Kevin Knight, Shivashankar B Nair, Artificial Intelligence, Third Edition, McGraw Hill Edition.
2. Russell Stuart Jonathan and Norvig Peter, Artificial Intelligence: A Modern Approach, 3rd Edition, Prentice Hall, 2010.
3. Rajiv Malhotra, Artificial Intelligence and the Future of Power, Rupa Publications.

Online Resources

1. <https://nptel.ac.in/courses/106105077>
2. <https://nptel.ac.in/courses/106102220>

PO- PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1			1	1		1					1	1
CO2	2	1	1	1	1								1	1
CO3	2	1	2	1	1			1					1	1
CO4	2	1	2	1	1	1		2			1		1	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	3	Semester	V		
Course Name	Web Technologies				
Code	NBSC3501				
Course Type	DSC13	L	T	P	Credit
Pre-Requisite	The concepts of Internet, HTML and CSS etc.	3	1	-	3
Course Objectives	To provide the basics of the internet, web terminologies, introducing scripting language concepts for developing client-side and server-side applications				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Understand basics of the Internet and World Wide Web and knowledge and skills for creation of web site considering both client and server-side programming.				
CO2	Learn basic skill to develop responsive web applications and understand different web extensions and web services standards.				
CO3	Understand basic concepts of Search Engine Basics and learn Web Service Essentials.				
CO4	Learn Rich Internet Application Technologies and get acquainted with Web Analytics 2.0				
Module	Course Contents	Contact Hrs.	Mapped CO		
1	Introduction to World Wide Web: Internet Standards, Introduction to WWW and WWW Architecture, Internet Protocols, Overview of HTTP, HTTP request – response, Generations of dynamic web pages. ([1] Chapter 2). Introduction to HTML and HTML5, HTML Tags, Anchors, Backgrounds, Images, Hyperlinks, Lists, Tables, Frames, HTML Forms. ([1] Chapter 4).	15	1		
2	CSS and Java Script: The need for CSS, Introduction to CSS, Basic syntax and structure, Inline Styles, Embedding Style Sheets, Linking External Style, Backgrounds, Manipulating Text, Margins and Padding, Positioning using CSS ([1] Chapter 8). Java script Introduction, Core features, Data types and Variables, Operators, Expressions, Functions, Objects, Array([1] Chapter 9).	15	2		

	JavaBean, Introduction to EJB ([1] Chapter 12).		
3	Database Connectivity: Database Basics, SQL, MySQL, PostgreSQL, JDBC API, Driver Types. Two-Tier and Three-Tier Models([1] Chapter 6). Connection Overview, Transactions, Driver Manager Overview, Statement Overview, Result Set Overview, Types of Result Sets, Prepared Statement Overview ([1] Chapter 7).	15	3
4	Java Applet and JSP: Java Web Programs and Applets, Web Application, Servlet, Servlet Life Cycle, Servlet Programming, Introduction to JSP, Life Cycle of a JSP Page, Translation and Compilation, Creating Static Content, Response and Page Encoding, Creating Dynamic Content, Using Objects within JSP Pages([1] Chapter 11).	15	4

Suggested Readings

1. J2EE: The complete Reference by James Keogh.
2. Java EE and HTML5 Enterprise Application Development (Oracle Press) by John Brock, Arun Gupta, GeertjanWielenga
3. Struts: The Complete Reference, 2nd Edition by James Holmes.

Online Resources

1. <https://www.digimat.in/nptel/courses/video/106105084/L01.html>
2. https://onlinecourses.swayam2.ac.in/nou24_cs09/preview

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1		1		2					1	1		1	
CO2	2				2	1		1		1	1			
CO3	2			1	2	1		1			1		1	1
CO4	2	1	2		2	1		2		2	1		1	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	3	Semester	V		
Course Name	Web Technologies LAB				
Code	NBSC3551				
Course Type	DSC13	L	T	P	Credit
Pre-Requisite	The concepts of Internet, HTML and CSS etc.	-	-	2	1
Course Objectives	To provide the basics of the internet, web terminologies, introducing scripting language concepts for developing client-side and server-side applications.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Create simple web pages using HTML, CSS and various kinds of tags.				
CO2	Program simple web applications using Java Script.				
CO3	Connect the web application with other databases.				
CO4	Create GUI based applications using servlets and applets.				

1. Design a Web page using different Text Formatting Tags.
2. Design a Web page with links to different Pages and allow navigation between Web Pages.
3. Design a Web page demonstrating all Style sheet types.
4. Design a Web page with Image maps.
5. Design a Web page with a Form that uses all types of controls.
6. Design a Web page demonstrating different semantics
7. Design a Web page with different Tables. Design Webpages using table so that the content appears well placed.
8. Design a Web page Embedding with multimedia features.
9. Using JavaScript design, a Web page that prints Factorial/Fibonacci series/any given series.
10. Design a form and validate all the controls placed on the form using Java Script
11. Write a JavaScript program to display all prime numbers between 1 and 100.
12. Write a JavaScript program to accept a number from the user and display the sum of its digits.
13. Write a program in JavaScript to accept a sentence from the user and display the number of words in it. (Do not use split () function).
14. Write a java script program to design simple calculator.

15. Develop an Applet that draws a circle. The dimension of the Applet should be 500 x 300 pixels. The circle should be centered in the Applet and have a radius of 100 pixels. Display your name centered in a circle (using drawOval() method).
16. Draw ten red circles in a vertical column in the center of the Applet.
17. Build an Applet that displays a horizontal rectangle in its center. Let the rectangle fill with color from left to right.
18. Develop an Applet that display the position of the mouse at the upper left corner of the Applet when it is dragged or moved. Draw a 10×10 pixel rectangle filed with black at the current mouse position.
19. Develop an Applet that contains one button. Initialize the label on the button to “start”, when the user presses the button, which changes the label between these two values each time the button is pressed.

Online Resources

1. <https://www.digimat.in/nptel/courses/video/106105084/L01.html>
2. https://onlinecourses.swayam2.ac.in/nou24_cs09/preview

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1		2	3	3	3		3	2	1	3		3	1
CO2	1	1	2		2	3		3	2	1	3		1	1
CO3	1		2	2	2	3		3	2	1	3		3	1
CO4	1			2	2	2		3	2	1	3		1	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	3	Semester	V		
Course Name	Information Security and Cyber Law				
Code	NBSC3502				
Course Type	DSC14	L	T	P	Credit
Pre-Requisite	Fundamental comprehension of how computers and networks function.	3	1	-	4
Course Objectives	To introduce the students the concepts of information security and different type of attacks in the cyber space cyber law.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Understand basics of Cryptography and Network Security.				
CO2	Secure a Message over Insecure channel by Various Means.				
CO3	Learn about how to Maintain the Confidentiality, Integrity and Availability of a Data.				
CO4	Understand various Protocols for Network Security to protect against the threats in the Networks.				
Module	Course Contents			Contact Hrs.	Mapped CO
1	Program Security and Threats: Secure programs, Non malicious Program Errors, Malicious Codes Virus, Trap Doors, Salami Attacks, Covert Channels, Control Against Program([1] Chapter 21). Threats and Protection in OS: Memory and Address Protection, Access Control, File Protection, User Authentication ([1] Chapter 15).			15	1
2	Introduction and Cryptography: Security Attacks, Computer Criminals, Security Services, Security Mechanisms ([1] Chapter 1).Cryptography: Substitution Ciphers, Transpositions Cipher, Confusion, Diffusion, ([1] Chapter 3) Symmetric,			15	2

	Asymmetric Encryption. DES Modes of DES, Uses of Encryption ([1] Chapter 4). Hash function, ([1] Chapter 11). Key exchange ([1] Chapter 10). Digital Signatures, Digital Certificates ([1] Chapter 13).		
3	Database Security: Requirements, Reliability, Integrity, Sensitive Data, Inference, Multilevel Security ([1] Chapter 12). Network Security: Threats in Networks, Security Controls ([1] Chapter 17). Firewalls ([1] Chapter 23) Intrusion Detection Systems ([1] Chapter 22). Secure E-mails ([1] Chapter 19).	15	3
4	Administrating Security: Security Planning, Risk Analysis, Organizational Security Policy, Physical Security. Ethical issues in Security: Protecting Programs and Data. Information and Law ([1] Chapter 24).	15	4

Suggested Readings

1. W. Stallings, Cryptography and Network Security: Principles and Practice, Seventh Edition, Pearson.
2. AtulKahate, Cryptography and Network Security, Second Edition, Tata McGraw-Hill.
3. W. Stallings; Network Security Essentials: Applications and Standards, 4/E, 2010.

Online Resources

1. <https://archive.nptel.ac.in/courses/106/106/106106129/>
2. https://onlinecourses.nptel.ac.in/noc23_cs127/preview

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1						1		1				1	1	
CO2	1		2	1	1	1					1	1	1	
CO3	2		1		1			2			1	1		1
CO4	2		1	1		1		2			1	2		1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	3	Semester	V		
Course Name	Software Engineering				
Code	NBSC3503				
Course Type	DSC15	L	T	P	Credit
Pre- Requisite	The concept of Software, Hardware Technologies and System	3	1	-	4
Course Objectives	To provides project-rich learning experiences to educate software engineers for success in a rapidly evolving Software development field.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Get basic knowledge and understanding of the analysis and Design of Complex systems.				
CO2	Apply software engineering Principles and techniques.				
CO3	Produce efficient, reliable, robust and cost-effective Software Solutions.				
CO4	Manage time, processes and resources effectively by prioritizing competing demands to achieve personal and team goals Identify and analyzes the common threats in each domain.				
Module	Course Contents	Contact Hrs.	Mapped CO		
1	Introduction: Introduction to Software, Software Application, System Evolution of Software, Software as System, Software Crisis, Significance of Software, Software characteristics, Changing nature of Software ([1] Chapter 1). Software Engineering as a Layered Technology, A Generic View of Software Engineering, Software Process framework, Framework and Umbrella Activities, Process Capability Maturity Model Integration (CMMI) ([1] Chapter 2).	15	1		

2	<p>Requirement Analysis & Specification: Software Requirement Analysis, Initiating Requirement Engineering Process, Requirement Analysis and Modeling Techniques: Software Process Models, Waterfall model, Prototyping, Flow Oriented Model. System Requirement Specification: Need for SRS, Characteristics of SRS, Components of SRS, Software Project Management, Software Project planning, Software Monitoring and Control, Estimation in Project Planning Process ([1] Chapter 2).</p>	15	2
3	<p>Risk Management: Software Risks, Risk Identification, Risk Projection and Risk Refinement, RMMM Plan ([1] Chapter 6). Quality Concepts, Software Quality Assurance, Software Reviews, Metrics for Process and Projects, Identify IT Project Risk, Risk Analysis and Assessment, Risk Strategies, Risk Monitoring and Control, Risk Response and Evaluation ([1] Chapter 8).</p>	15	3
4	<p>Software Design & Testing: Design Objectives, Design Concepts, Architectural Design Elements, Software Architecture, Data Design at the Architectural Level and Component Level, Mapping of Data Flow into Software Architecture, Modeling Component Level Design ([1] Chapter 14). Software Testing Fundamentals: Strategic Approach to Software Testing, Functional Testing, Structural Testing, Testing Strategies for Conventional Software, Validation Testing, System testing, Black-Box Testing, White-Box Testing, Strategic Issues in Testing ([1] Chapter 17).</p>	15	4

Suggested Readings

1. Roger S. Pressman, Software Engineering: A practitioner's approach, McGraw Hill.
2. Rajib Mall, Fundamentals of Software Engineering, Prentice Hall India.
3. K.K. Aggarwal and Y. Singh, Software Engineering (2nd Edition), New Age International Publishers, 2008.

Online Resources

1. <https://archive.nptel.ac.in/courses/106/101/106101061/>
2. <https://archive.nptel.ac.in/courses/106/105/106105182/>

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1				1	1			1		1	1
CO2	1	1	1			1	1	1			1		1	1
CO3	1	1	1			1	1	2			2		1	1
CO4	1	1	1			2	1	2			2		1	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	3	Semester	VI		
Course Name	Machine Learning				
Code	NBSC3601				
Course Type	DSC16	L	T	P	Credit
Pre-Requisite	The Concepts of Artificial Intelligence	3	1	-	4
Course Objectives	To understand the basic theory underlying machine learning.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Differentiate between Supervised, Unsupervised Machine Learning approaches				
CO2	Choose appropriate Machine Learning Algorithm for solving a problem				
CO3	Design and Adapt existing Machine Learning Algorithms to suit Applications.				
CO4	Understand the underlying mathematical relationships across various machine learning Algorithms.				
Module	Course Contents	Contact Hrs.		Mapped CO	
1	Introduction: Definition of Learning Systems, Goals and Applications of Machine Learning. Aspects of developing a learning system: Training Data, Testing Data, Concept Representation. Concept of Machine Learning, Applications of Machine Learning, Classification, Regression, Supervised Learning, Unsupervised Learning, Reinforcement Learning ([1] Chapter 1).Supervised Learning: Model selection and Generalization, Dimensions of a Supervised Machine Learning Algorithm([1] Chapter 2). Bayesian Decision Theory: Losses and risks, Discriminant	15		1	

	Functions, Utility Theory, Association Rules([1] Chapter 3).		
2	Parametric Methods: Maximum Likelihood Estimation: Bernoulli Density, Multinomial Density, Gaussian(Normal) Density. Parametric Classification, Tuning Model Complexity: Bias and Variance Dilemma, Model Selection procedures ([1] Chapter 4). Multivariate Methods: Parameter Estimation, Estimation of missing values, Multivariate Normal Distribution, Multivariate Classification, Tuning Complexity, Multivariate Regression([1] Chapter 5).	15	2
3	Dimensionality Reduction: Principal Component Analysis, factor analysis, Multidimensional Scaling, Linear Discriminant Analysis, ISOMap, Locally Linear Embedding ([1] Chapter 6).Clustering and Unsupervised Learning:Learning from Unclassified Data. Clustering, Hierarchical Agglomerative Clustering, K-means Clustering, Hierarchical Clustering([1] Chapter 7). Nonparametric Methods: Histogram Estimator, Kernel Estimator.([1] Chapter 8).	15	3
4	Artificial Neural Networks: Introduction, Model Representation, Gradient Descent vs. Perceptron Training, Stochastic Gradient Descent,Back Propagation Algorithm.([1] Chapter 11).Classification Problems in Language: Word-sense Disambiguation, Hidden Markov models (HMM's) ([1] Chapter 15).	15	4

Suggested Readings

1. EthemAlpaydin, "Introduction to Machine Learning" 2nd Edition, The MIT Press, 2009.
2. Tom M. Mitchell, "Machine Learning", First Edition by Tata McGraw-Hill Education 2013.
3. Christopher M. Bishop, "Pattern Recognition and Machine Learning" by Springer, 2007.

Online Resources

1. <https://archive.nptel.ac.in/courses/106/105/106105152/>
2. <https://www.digimat.in/nptel/courses/video/106105152/L01.html>

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2		2	2		1		1			1		1	1
CO2	2		2	1	2	2		2		2	2		1	1
CO3	2		1	1	2	2		2		2	2		1	1
CO4	2		2	1	2	1		2		1	2		1	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	3	Semester	VI		
Course Name	Cloud Computing				
Code	NBSC3602				
Course Type	DSC17	L	T	P	Credit
Pre-Requisite	Knowledge of database and computer networks	3	1	-	4
Course Objectives	To provide students with the fundamentals and sound foundation of the Cloud Computing so that they are able to start using and adopting Cloud Computing services and tools in their real life.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Analyze the trade-offs between deploying applications in the cloud and over the local infrastructure and Compare the advantages and disadvantages of various cloud computing platforms.				
CO2	Deploy applications over commercial Cloud Computing infrastructures such as Amazon Web Services, Windows Azure, and Google AppEngine.				
CO3	Analyze the Performance, scalability, and Availability of the underlying Cloud technologies and software.				
CO4	Identify security and Privacy issues in Cloud Computing and Solve a real-world problem using cloud computing through group collaboration.				
Module	Course Contents			Contact Hrs.	Mapped CO
1	Overview of Cloud Computing Paradigm: Recent trends in Computing, Grid Computing, Cluster Computing, Distributed Computing, Utility Computing, Cloud Computing, Introduction to Cloud Computing; Evolution of Cloud Computing, Cloud Service Providers: Benefits and limitations of Cloud Computing ([1] Chapter 1).			15	1

2	<p>Cloud Computing Architecture: Comparison with traditional Computing Architecture (client/server) ([1] Chapter 2). Services provided at various levels; Service Models- Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS). How Cloud Computing works, Deployment Models- Public Cloud, Private Cloud, Hybrid Cloud, Community Cloud, Case study of NIST Architecture ([1] Chapter 2).</p>	15	2
3	<p>Information Storage in Cloud Computing: Introduction- Objectives, Storage as a Service, Storage Providers: Amazon Simple Storage Service, Nirvanix- Google Big Table Data store Mobile Me: Live Mesh, Storage Security, Merits and Demerits of Storage: Public, Private, and Hybrid Clouds: A Comparison, Examining the Economics of the Private Cloud, Case study of AWS. ([1] Chapter 5).</p>	15	3
4	<p>Cloud Security: Infrastructure Security: Network Level Security, Host Level Security, Application level Security, Data Security and Storage. Data privacy and security issues, Jurisdictional Issues Raised by Data Location, Authentication in Cloud Computing ([1] Chapter 13).</p>	15	4

Suggested Readings

1. Essentials of Cloud Computing, K Chandrasekaran, CRC Press.
2. Cloud Computing: Principles and Paradigms, Editors: Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, Wile, 2011
3. Cloud Computing Bible, Barrie Sosinsky, Wiley-India, 2010

Online Resources

1. <https://archive.nptel.ac.in/courses/106/105/106105167/>
2. <https://archive.nptel.ac.in/courses/106/105/106105223/>

PO- PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1		2	2		1		1			1		1	1
CO2	2		2	1	1	2		2		2	2		1	1
CO3	2		1	2	2	2		1		2	1		1	1
CO4	1		2	1	1	1		2		1	2		2	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science					
Year	3	Semester			VI	
Course Name	Soft Computing					
Code	NBSC3603					
Course Type	DSC18	L	T	P	Credit	
Pre-Requisite	Knowledge of Artificial Intelligence.	3	1	-	4	
Course Objectives	To introduce Soft Computing concepts and techniques and foster their abilities in designing and implementing soft computing based solutions for real-world. Introduce students to Genetic Algorithm, fuzzy systems, fuzzy logic, Artificial Neural Networks and its applications.					
Course Outcomes: Upon successful completion of syllabus, a student will be able to:						
CO1	Comprehend the fuzzy logic and the concept of fuzziness involved in various systems and fuzzy set theory.					
CO2	Understand the concepts of fuzzy sets, knowledge representation using fuzzy rules, approximate reasoning, fuzzy inference systems, and fuzzy logic					
CO3	Understand the fundamental theory and concepts of neural networks, Identify different neural network architectures, algorithms, applications and their limitations.					
CO4	Identify different neural network architectures, algorithms, applications and their limitations.					
Module	Course Contents				Contact Hrs.	Mapped CO
1	Introduction - Introduction to Statistical, Syntactic and Descriptive Approaches features and feature extraction, Learning, Bayes Decision Theory, Introduction Continuous Case-2, Category Classification, Minimum Error Rate Classification, Classifiers, Discriminant functions				15	1

	and Decision surfaces, Error Probabilities and Integrals, Normal Density, Discriminant functions for normal density. ([1] Chapter 3)		
2	Introduction to Genetic Algorithm: Genetic Operators and Parameters, Genetic Algorithms in Problem Solving, Theoretical Foundations of Genetic Algorithms, Implementation Issues, Systems. ([2] Chapter 1, Chapter 2)	15	2
3	Neural Model and Network Architectures: Perceptron Learning, Supervised Hebbian Learning, Back-propagation, Associative Learning, Competitive Networks, Hopfield Network, Computing with Neural Nets and Applications of Neural Network. Support Vector Machines.([5] Chapter 2, Chapter 3)	15	3
4	Introduction to Fuzzy Sets: Operations on Fuzzy Sets, Fuzzy Relations, Fuzzy Measures, Applications of Fuzzy Set Theory to different branches of Science and Engineering.([5] Chapter 6, Chapter 7)	15	4

Suggested Readings

1. EthemAlpaydin, "Introduction to Machine Learning" 2nd Edition, The MIT Press, 2009.
2. M. Mitchell, AnIntroduction to Genetic Algorithms, Prentice-Hall, 1998.
3. D. E. Goldberg, Genetic Algorithms in Search, Optimization, and MachineLearning, Addison-Wesley, 1989.

Online Resources

1. <https://archive.nptel.ac.in/courses/106/105/106105173/>
2. <http://www.digimat.in/nptel/courses/video/106105173/L01.html>

PO- PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1		1	2		2		1			1		1	1
CO2	2		2	1	2	2		2		2	2		1	1
CO3	2		1	1	2	1		2		1	1		2	1
CO4	2		2	2	1	1		2		1	2		2	2

Program	B.Sc. (Hons./ Hons. with research) Computer Science					
Year	4	Semester			VII	
Course Name	Internet of Things					
Code	NBSC3701					
Course Type	DSC19	L	T	P	Credit	
Pre-Requisite	Knowledge of Programming and Networks	3	1	-	4	
Course Objectives	Students will be explored to the interconnection and integration of the physical world and the cyber space. They are also able to design & develop IOT Devices.					
Course Outcomes: Upon successful completion of syllabus, a student will be able to:						
CO1	Learn the concepts of Sensors, Wireless Network and Internet and Implement use of Devices in IoT Technology.					
CO2	Learn the different IoT Technologies like Micro-controller, Wireless communication like Bluetooth, GPRS, Wi-Fi and Storage and Embedded Systems.					
CO3	Understand how to program on embedded and mobile platforms including different Microcontrollers like ESP8266, Raspberry Pi, Arduino and Android programming.					
CO4	Understand how to make Sensor Data available on the Internet (data acquisition) and understand how to Analyze and Visualize Sensor Data.					
Module	Course Contents				Contact Hrs.	Mapped CO
1	(Introduction to IoT Sensors and Actuators) Introduction to IoT: Definition, Characteristics, Applications, Evolution, Enablers, Connectivity Layers, Addressing, Networking and Connectivity Issues, Network Configurations, Multi-Homing, Sensing: Sensors and Transducers, Classification,				15	1

	Different Types of Sensors, Errors, Actuation: Basics, Actuator Types: Electrical, Mechanical Soft Actuators. Introduction to Networking, Communication Protocols and Machine-to-Machine Communication ([1] Chapter 8).		
2	Basics of Networking: Communication Protocols, Sensor Network, Machine to Machine Communication (IoT Components, Inter-Dependencies, SoA, Gateways, Comparison Between IoT& Web, Difference Protocols, Complexity of Networks, Wireless Networks, Scalability, Protocol Classification, MQTT & SMQTT, IEEE 802.15.4, Zigbee, Arduino Programming Interoperability in IoT, Introduction to Arduino Programming, Integration Of Sensors and Actuators with Arduino ([1] Chapter 10).	15	2
3	Python Programming and Raspberry Pi: Introduction to Python Programming, Introduction to Raspberry Pi, Implementation of IoT with Raspberry Pi, Implementation of IoT with Raspberry Pi. Introduction to Data Analytics. ([2] Chapter 1, Chapter 2)	15	3
4	Security, Sensor-Cloud Architecture:Introduction to cloud computing. View and Dataflow. FOG Computing and Case Studies: FOG Computing: Introduction, Architecture, Need, Applications and Challenges, Industrial IoT, Case Studies: Agriculture, Healthcare, Activity Monitoring ([1] Chapter 6).	15	4

Suggested Readings

1. "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", by Pethuru Raj and Anupama C. Raman (CRC Press).
2. Programming the Raspberry Pi: Getting Started with Python, by Simon Monk, McGraw Hill Education
3. "Internet of Things: A Hands-on Approach", by A Bahga and Vijay Madisetti (Universities Press).

Online Resources

1. <https://archive.nptel.ac.in/courses/106/105/106105166/>
2. <https://www.digimat.in/nptel/courses/video/106105166/L21.html>

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1		2	1		2		1			2		1	1
CO2	2		2		1	2		1		1			1	1
CO3	1		1	2		1				1	1		2	1
CO4	1		2		1	1		2		1	2		2	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	4	Semester			VIII
Course Name	Digital Image Processing				
Code	NBSC3801				
Course Type	DSC20	L	T	P	Credit
Pre-Requisite	Knowledge of Linear Algebra, Probability and Statistics, Signals and systems, Basic Programming skills.	3	1	-	4
Course Objectives	To study the image fundamentals and mathematical transforms necessary for image processing image enhancement techniques, image restoration procedures and image compression procedures.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Familiarize with the image fundamentals and mathematical transforms necessary for image processing.				
CO2	Make the students understand the image enhancement techniques				
CO3	Make the students understand the image restoration and re-construction procedures.				
CO4	Familiarize with the image segmentation procedures.				
Module	Course Contents	Contact Hrs.		Mapped CO	
1	Introduction of Light: Brightness Adaption and Discrimination, Pixels, Coordinate Conventions, Imaging Geometry, Perspective Projection, Spatial Domain Filtering, Sampling and Quantization. Spatial Domain Filtering Intensity Transformations, Smoothing Filters, Sharpening Filters, Gradient and Laplacian ([1] Chapter 1-3).	15		1	
2	Filtering in the Frequency Domain Fourier Transforms and properties: FFT (Decimation in Frequency and Decimation in Time Techniques). Image Restoration Basic Framework, Interactive Restoration, Image deformation and Geometric Transformations, Image Morphing, Restoration techniques.([1] Chapter 4-5).	15		2	
3	Image Compression Encoder-Decoder model: Types of Redundancies, Lossy and Lossless Compression,	15		3	

	Huffman Coding, Arithmetic Coding, LZW Coding, Transform Coding, Sub-Image Size Selection, Blocking Artifacts ([1] Chapter 8). JPEG-2000 Encoding, Digital Image Watermarking ([1] Chapter 7).		
4	Morphological Image Processing: Basics, SE, Erosion, Dilation, Opening, Closing, Hit- or-Miss Transform, Boundary Detection, Hole Filling, Connected Components, Convex Hull. ([1] Chapter 9).Image Segmentation: Boundary Detection Based Techniques, Point, Line detection, Edge detection, Edge Linking.([1] Chapter 10-11).	15	4

Suggested Readings

1. R C Gonzalez, R E Woods, Digital Image Processing, 3rd Edition, Pearson Education 2008.
2. A K Jain, Fundamentals of Digital image Processing, Prentice Hall of India.1989.
3. K R Castleman, Digital Image Processing, Pearson Education.1996

Online Resources

1. <https://archive.nptel.ac.in/courses/117/105/117105135/>
2. <http://acl.digimat.in/nptel/courses/video/105107160/L03.html>

PO- PSO	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1 0	PO1 1	PO 12	PSO1	PSO2
CO1	1	1	1				1	1			1		1	1
CO2	1	1	1			1	1	1			1		1	1
CO3	1	1	1			1	1	2			2		1	1
CO4	1	1	1			2	1	2			2		1	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science					
Year	3	Semester			V	
Course Name	Fundamental of Data Science					
Code	NBSCE3501					
Course Type	DSE1A	L	T	P	Credit	
Pre-Requisite	Basic knowledge of Mathematics Statistics and a programming language.	3	1	-	4	
Course Objectives	To provide the students with the basic knowledge of Data Science, develop solutions using Data Science tools and to introduce them to Python packages and their usability.					
Course Outcomes: Upon successful completion of syllabus, a student will be able to:						
CO1	Demonstrate advanced skills in Data Acquisition and Management.					
CO2	Demonstrate advanced skills in Data Analysis Techniques using Mathematics and Statistical Principles.					
CO3	Demonstrate advanced skills in Data Presentation, Communication, and Visualization.					
CO4	Demonstrate the ability to make Data-Driven Decisions.					
Module	Course Contents				Contact Hrs.	Mapped CO
1	R Programming Basics: Overview of R, R data types and objects, reading and writing data, Control structures, functions, scoping rules, dates and times([1] Chapter 4), Loop functions, debugging tools. ([1] Chapter 18).				15	1
2	Getting and Cleaning Data: Turning Data into Actionable Knowledge, Introduction to the tools that will be used in building Data Analysis Software. Obtaining data from the Web, from APIs, from databases and from colleagues in various formats:				15	2

	Basics of Data Cleaning and making data “tidy” ([1] Chapter 4).		
3	Exploratory Data Analysis: Essential Exploratory techniques for Summarizing Data, Distribution of Data, Graphical Representation, Outlier detection, Correlation analysis, Summary statistics. ([1] Chapter 8).	15	3
4	Reproducible Research: Concepts and tools behind reporting Modern Data Analyses in a Reproducible Manner. Document writing using R Markdown, Integrate live R code into a literate Statistical Program, compile R Markdown Documents using knitr. ([7] Chapter 16).	15	4

Suggested Readings

1. R Programming for Data Science Roger D. Peng, Leanpub, 2015
2. RachelSchutt, Cathy O’Neil, “Doing Data Science: Straight Talk from the Frontline” by Schroff/O’Reilly, 2013.
3. John W. Foreman, “Data Smart: Using data Science to Transform Information intoInsight” by John Wiley & Sons, 2013.

Online Resources

1. <https://archive.nptel.ac.in/courses/106/106/106106179/>
2. https://onlinecourses.swayam2.ac.in/imb23_mg64/preview

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1		2	1		2		1			2		1	1
CO2	2		2		1	2		1		1			1	1
CO3	1		1	2		1				1	1		2	1
CO4	1		2		1	1		2		1	2		2	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	3	Semester			V
Course Name	Computer Vision				
Code	NBSCE3502				
Course Type	DSE1B	L	T	P	Credit
Pre-Requisite	Student needs to have some background knowledge in mathematics, programming, and data structures.	3	1	-	4
Course Objectives	<p>Identify basic concepts, terminology, theories, models and methods in the field of computer vision.</p> <p>Describe basic methods of computer vision related to multi-scale representation, edge detection and detection of other primitives, stereo, motion and object recognition.</p>				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Have a complete knowledge on various computer vision available in literature.				
CO2	Have realized some satisfaction of having learnt that computer vision is indeed useful in computer science and engineering and thereby concluding that no mistake has been made in studying this course.				
CO3	Gain some confidence on how to deal with problems which may arrive in computer science and engineering in near future.				
CO4	Construct simple mathematical proofs				
Module	Course Contents			Contact Hrs.	Mapped CO
1	Image formation and camera calibration: Introduction to computer vision, geometric camera models, orthographic and perspective projections, weak perspective projection, intrinsic and extrinsic camera parameters, linear and nonlinear approaches of camera calibration. ([1] Chapter 5, Chapter 12)			15	1
2	Feature detection and matching: Edge detection, interest points and corners, local image features, feature matching and Hough transform, model			15	2

	fitting and RANSAC, scale invariant feature matching. ([1] Chapter 8)		
3	Stereo Vision: Stereo camera geometry and epipolar constraints, essential and fundamental matrix, image rectification, local methods for stereo matching: correlation and multi-scale approaches, global methods for stereo matching: order constraints and dynamic programming.([1] Chapter 12)	15	3
4	Shape from Shading: Modeling pixel brightness, reflection at surfaces, the Lambertian and specular model, area sources, photometric stereo: shape from multiple shaded images, modeling inter-reflection, shape from one shaded image ([1] Chapter 2).	15	4

Suggested Readings

1. Forsyth, D. A. and Ponce, J., "Computer Vision: A Modern Approach", Prentice Hall, 2ndEd.
2. Richard Szeliski, R., "Computer Vision: Algorithms and Applications", Springer.
3. Hartley,R. and Zisserman, A.,"Multiple View Geometry in Computer Vision",Cambridge University Press.

Online Resources

1. <https://archive.nptel.ac.in/courses/106/105/106105216/>
2. <https://archive.nptel.ac.in/courses/106/106/106106224/>

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1			1		2		1			2		1	1
CO2	2		2		1			1		1				1
CO3	1					1				1	1			
CO4	1		2		1	1		2		1	2		2	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	3	Semester		V	
Course Name	Block Chain Technology				
Code	NBSCE3503				
Course Type	DSE1C	L	T	P	Credit
Pre-Requisite	Knowledge of Cryptography	3	1	-	4
Course Objectives	Technical understanding of Blockchain technologies and develop familiarity of current technologies, tools, and implementation strategies.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Explain design principles of Bitcoin and Ethereum and Nakamoto consensus.				
CO2	Explain the Simplified Payment Verification protocol.				
CO3	List and describe differences between proof-of-work and proof-of-stake consensus.				
CO4	Evaluate security, privacy and efficiency of a given blockchain system.				
Module	Course Contents			Contact Hrs.	Mapped CO
1	Blockchain: Introduction, Advantage over conventional distributed database, Blockchain Network, Mining Mechanism, Distributed Consensus, Merkle Patricia Tree Gas Limit, Transactions and Fee, Anonymity, Reward Chain Policy([4] Chapter 1).			15	1
2	Life of Blockchain application, Soft & Hard Fork, Private and Public block chain ([4] Chapter 1). Cryptocurrency: History,Distributed Ledger, Bitcoin protocols-Mining strategy and rewards, Ethereum-Construction, DAO, Smart Contract, GHOST Vulnerability, Attacks, Sidechain, Name coin([4] Chapter 5).			15	2
3	Cryptocurrency Regulation: Stakeholders, Roots of Bitcoin, LegalAspects-Cryptocurrency Exchange, Black Market and Global Economy. Applications: Internet of Things, Medical Record Management System, Domain Name Service and future of Blockchain ([4] Chapter 5).			15	3
4	Distributed Consensus: Nakamoto consensus, Proof of Work, Proof of Stake, Proof of Burn, Difficulty Level Sybil Attack, Energy utilization and alternate ([4] Chapter 1).			15	4

Suggested Readings

1. Andreas M. Antonopoulos, Mastering Bitcoin: Unlocking Digital Cryptocurrencies, "O'ReillyMedia,Inc.", 03-Dec-2014 -Business &Economics.
2. Dr.GavinWood,“ETHEREUM:ASecureDecentralizedTransactionLedger,”Yellowpaper.2014.
3. Antony Lewis, The Basics of Bitcoins and Blockchains: An Introduction to Cryptocurrenciesand the Technology that Powers Them(Cryptography, Crypto Trading, Digital Assets, NFT)Paperback– April13,2021.

Online Resources

1. <https://archive.nptel.ac.in/courses/106/104/106104220/>
2. <https://archive.nptel.ac.in/courses/106/105/106105235/>

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1			2	1		2		1			2		1	1
CO2	1		2			1		1		1			1	1
CO3	1		1	2		1					1		1	1
CO4	2		2		1	1		2		1	2		1	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	3	Semester	VI		
Course Name	E-Commerce				
Code	NBSCE3601				
Course Type	DSE2A	L	T	P	Credit
Pre-Requisite	The basic concepts of Computer and Communication Technologies.	3	1	-	4
Course Objectives	To provide an introduction to information systems for business and management. It is designed to familiarize students with organizational, managerial and technical foundation for understanding information systems.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Understand the basic concepts and technologies used in the field of management information systems.				
CO2	Have the knowledge of the different types of management information systems.				
CO3	Understand the processes of developing and implementing information systems.				
CO4	Be aware of the ethical, social, and security issues of information systems.				
Module	Course Contents			Contact Hrs.	Mapped CO
1	E-commerce and its Technological Aspects: Overview of Developments in Information Technology and Defining E-Commerce: The scope of E commerce, Electronic Market, Electronic Data Interchange, Internet Commerce, Benefits and Limitations of E-Commerce, Difference between E-Business & E-Commerce.([1] Chapter 1). Produce a Generic framework for E-Commerce, Architectural Framework of Electronic Commerce, Web based E-Commerce Architecture ([1] Chapter 5).			15	1
2	Electronic Data Interchange: Benefits of EDI, EDI technology, EDI standards, EDI communications, EDI Implementation, EDI Agreements, EDI Security. Electronic Payment Systems, Need of Electronic Payment System: Study and Examine the Use of Electronic Payment system and the Protocols used, Study Electronic Fund Transfer and Secure Electronic Transaction Protocol for Credit Card Payment ([1] Chapter 19). Digital Economy: Identify the methods of Payments on the Net –			15	2

	Electronic Cash, Cheques and Credit Cards on the Internet. B2B and B2C E-Commerce business models ([1] Chapter 20).		
3	Security in E Commerce: Threats in Computer Systems: Virus, Cyber Crime Network Security: Encryption, Protecting Web server with a Firewall, Financial frauds, Firewall and the Security Policy, Network Firewalls and Application Firewalls, Proxy Server ([1] Chapter 13).	15	3
4	Issues in E Commerce: Understanding Ethical, Social and Political issues in E-Commerce: A model for Organizing the issues, Basic Ethical Concepts, Analyzing Ethical Dilemmas, Candidate Ethical principles([1] Chapter 31). Privacy and Information Rights: Information collected at E-Commerce Websites, Concept of Privacy, Legal protections Intellectual Property Rights: Types of Intellectual Property protection, E-Governance ([1] Chapter 41).	15	4

Suggested Readings

1. Elias. M. Awad, "Electronic Commerce", Prentice-Hall of India Pvt Ltd.
2. RaviKalakota, Andrew B. Whinston, "Electronic Commerce-A Manager's guide", Addison-Wesley.
3. Efraim Turban, Jae Lee, David King, H.Michael Chung, "Electronic Commerce: A Managerial Perspective", Addison-Wesley.

Online Resources

1. <https://archive.nptel.ac.in/courses/110/105/110105083/>
2. https://onlinecourses.swayam2.ac.in/nou21_cm14/preview

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1				1	1			1		1	1
CO2	1	1	1			1	1	1			1		1	1
CO3	1	1	1			1	1	2			2		1	1
CO4	1	1	1			2	1	2			2		1	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	3	Semester		VI	
Course Name	Management Information System				
Code	NBSCE3602				
Course Type	DSE2B	L	T	P	Credit
Pre-Requisite	Student must have basic knowledge of Computer and Communication technologies.	3	1	-	4
Course Objectives	To provide concepts of Management, Information and System for decision making on planning, initiating, organizing, and controlling the various operations of the subsystems of the organization				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Understand the fundamentals of Management Concepts.				
CO2	Clear the understanding of Management Information System and its importance in current scenario.				
CO3	Learn the Concepts of Planning and Control processes in an organization.				
CO4	Understand, How to Manage Information Technology and also Explore ERP and Supply Chain				
Module	Course Contents	Contact Hrs.		Mapped CO	
1	Concepts of Management and System: Basic Concepts, Overview of Management Concepts, Functions of Management, Levels of Management, Top Level Management, Middle Level Management, Low Level Management, Concept of a System, System Concepts, Components of a System, Types of System, Data and Information([1] Chapter 1)	15		1	
2	Information System& MIS: Need for Information Systems, Roles of Information System in Business Types of Information System, Effectiveness and Efficiency Criteria in Information System. MIS Overview: Definition and Concept of a	15		2	

	Management Information System, MIS versus Data Processing, MIS & Decision Support System, MIS & Information Resources Management, End User Computing, Structure of a Management Information system. ([1] Chapter 2)		
3	Concepts of Planning and Control: Concept of Organizational Planning, The Planning Process, Computational Support for Planning, Characteristics of Control Process, The Nature of Control in an Organization. Business Applications of Information Technology: Internet and Electronic Commerce, Intranet, Extranet and Enterprise Solutions, Information System for Business Operations and Managerial Decision Support ([3] Chapter 12).	15	3
4	Managing Information Technology: Enterprise and Global Management, Security and Ethical Challenges, Planning and Implementing Changes. Advanced Concepts in Information System: Enterprise Resource Planning, Supply Chain Management ([3] Chapter 4-7).	15	4

Suggested Readings

1. Brian, "Introduction to Information System", Tata Mcgraw-hill Education Pvt. Ltd.
2. Murdick, "Information System for Modern Management", PHI Learning Private Limited, Delhi India.
3. Jawadekar, "Management Information System", Tata Mcgraw-Hill Education Pvt. Ltd.

Online Resources

1. <https://archive.nptel.ac.in/courses/110/105/110105148/>
2. <https://archive.nptel.ac.in/courses/122/105/122105022/>

PO- PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1		2	1		2		1			2		1	1
CO2	1	1			1					1			1	1
CO3	1		1	2		1				1	1		2	1
CO4	1				1			2		1	2		2	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	3	Semester	VI		
Course Name	Research Methodologies				
Code	NBSCE3603				
Course Type	DSE2C	L	T	P	Credit
Pre-Requisite	Knowledge of Basic Statistics and Computer Science	3	1	-	4
Course Objectives	To provides a framework and guidelines for researchers to clearly define research questions, hypotheses, and objectives.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Understand the fundamentals of Management Concepts. Search, select and critically analyze research articles and papers and Prepare a literature review.				
CO2	Formulate, evaluate research questions and Develop a research proposal or industry project plan.				
CO3	Gain experience with instrument development and data collection methods.				
CO4	Gain experience with ethics proposals.				
Module	Course Contents			Contact Hrs.	Mapped CO
1	Foundations of Research: Meaning, Objectives, Motivation, Utility. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method - Understanding the language of Research - Concept, Construct, Definition, Variable. Research Process. Hypothesis - Qualities of a good Hypothesis: Null Hypothesis & Alternative Hypothesis ([3] Chapter 1).			15	1
2	Research Design: Features of a good research design - Exploratory Research Design, Descriptive Research Design and Experimental Design. Qualitative and Quantitative Research, Levels of measurement. Sampling: Concepts of Statistical Population, Characteristics of a good sample ([3] Chapter 3).			15	2
3	Data Analysis: Data Preparation - Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis- Cross tabulations and Chisquare test ([3] Chapter 7).			15	3

4	Interpretation of Data and Paper Writing- Layout of a Research Paper, Journals in Computer Science, Impact factor of Journals, publishing of papers. Ethical issues related to publishing, Plagiarism and Self-Plagiarism ([3] Chapter 14).	15	4
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Suggested Readings

1. Business Research Methods- Donald Cooper & Pamela Schindler, TMGH, 9th editions.
2. Business Research Methods- Alan Bryman& Emma Bell, Oxford University Press.
3. Research Methodology- C. R. Kothari.

Online Resources

1. <https://archive.nptel.ac.in/courses/127/106/127106227/>
2. <https://nptel.ac.in/courses/121106007>

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1		1	2	2	1	1							1	1
CO2	2		2	2	1	2								1
CO3	2		1			2		1			1	1		1
CO4	2	2	2	1	2	2		1				2	1	

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	4	Semester	VII		
Course Name	Big Data Analysis				
Code	NBSCE3701				
Course Type	DSE3A	L	T	P	Credit
Pre-Requisite	Knowledge of database, cloud and networks.	3	1	-	4
Course Objectives	To know the fundamental concepts of big data and analytics and explore tools and practices for working with big data				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Provide an overview of an exciting growing field of Big Data Analytics.				
CO2	Introduce the tools required to Manage and Analyze Big Data like Hadoop, NoSql,MapReduce.				
CO3	Teach the Fundamental techniques and Principles in achieving big Data Analytics with scalability and Streaming Capability.				
CO4	Have skills that will help them to solve Complex real-World problems in for Decision Support				
Module	Course Contents			Cont act Hrs.	Mapped CO
1	Introduction to Big Data: Introduction: ([1] Chapter 1). Hadoop distributed file System, Big Data and its Importance, Drivers for Big data ([1] Chapter 2). Big data Analytics, Big Data Applications ([1] Chapter 9).Algorithms using Map Reduce, Matrix-Vector Multiplication by Map Reduce ([1] Chapter 3).			15	1
2	Introduction to Hadoop: Big Data: Apache Hadoop&Hadoop Eco-System ([1] Chapter 1) Moving Data in and out of Hadoop , Understanding Inputs and Outputs of Map Reduce, ([2] Chapter 2) Data Serialization ([2] Chapter 4).			15	2
3	Hadoop Architecture: Hadoop Architecture ([2] Chapter 3) Hadoop Storage: HDFS, Common			15	3

	HadoopShell Commands, Anatomy of File Write and Read, Name Node, Secondary Name Node, and Data Node ([2] Chapter 3). Hadoop Map Reduce Paradigm, Map and Reduce tasks, Job, Task trackers ([2] Chapter 5). HDFS Administering, Monitoring & Maintenance ([2] Chapter 9).		
4	Hadoop Ecosystem and Yarn: Hadoop Ecosystem Components ([2] Chapter 11) Schedulers, Fair and Capacity, Hadoop2.0: New Features Name Node, High Availability, HDFS Federation, MRv2, YARN ([2] Chapter 6).	15	4

Suggested Readings

1. Boris lublinsky, Kevin t. Smith, Alexey Yakubovich, “Professional Hadoop Solutions”, Wiley, ISBN: 9788126551071, 2015.
2. Tom White, “HADOOP: The definitive Guide”, O Reilly 2012.
3. Chris Eaton, Dirk deroos et al., “Understanding Big data”, McGraw Hill, 2012.

Online Resources

1. <https://archive.nptel.ac.in/courses/106/104/106104189/>
2. <https://www.digimat.in/nptel/courses/video/106104189/L01.html>

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1		2	1		2		1					1	1
CO2	2	1			1					1			1	
CO3	1		1	2		1				1	1			
CO4	2		1		1			2		1			2	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	4	Semester	VII		
Course Name	Data Mining & Warehousing				
Code	NBSCE3702				
Course Type	DSE3B	L	T	P	Credit
Pre-Requisite	Students must have strong knowledge of relational Database Management System and computer language.	3	1	-	4
Course Objectives	To introduce the concepts of data ware house and data mining, which gives a complete description about the principles, architectures, applications, design and implementation of data mining and data ware housing concepts				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Understand data mining principles and techniques and Building basic terminology.				
CO2	Learn how to produce a quantitative analysis report/memo with the necessary information to make decisions.				
CO3	Get the overview of the developing areas - web mining, text mining, and ethical aspects of data mining.				
CO4	Develop and apply critical thinking, problem-solving, and decision-making skills.				
Module	Course Contents			Contact Hrs.	Mapped CO
1	Data Mining: Definition & Functionalities, Data Preprocessing, Data Cleaning: Missing Values, Noisy Data, Inconsistent Data, Data Integration and Transformation, Data Reduction, Data Cube Aggregation, Dimensionality reduction, Data Compression, Numerosity Reduction, Clustering,			15	1

	Discretization and Concept Hierarchy generation ([2] Chapter 1, Chapter 3).		
2	Statistical measures in large Databases, Measuring Central Tendency, Measuring Dispersion of Data, Range, Quartiles, Outliers, Box plots, Variance, Standard Deviation, Graph Displays of Basic Statistical class Description, Mining Association Rules in Large Databases ([2] Chapter 2).	15	2
3	Classification: Decision tree, Bayesian Classification, Classification by Back propagation, Multilayer feed-forward Neural Network, Back propagation Algorithm, Classification methods, K-nearest neighbor classifiers, Genetic Algorithm, Cluster Analysis ([2] Chapter 8, Chapter 9).	15	3
4	Data Warehousing and OLAP Overview, Definition, Delivery Process, Difference between Database System and Data Warehouse, Multi- Dimensional Data Model, Three Tier Architecture, Data Marting, Aggregation, Historical information, Query Facility, OLAP function and Tools, OLAP Servers, ROLAP, MOLAP, HOLAP ([2] Chapter 4).	15	4

Suggested Readings

1. M.H. Dunham, "Data Mining: Introductory and Advanced Topics" Pearson Education.
2. Jiawei Han, MichelineKamber, "Data Mining Concepts & Techniques", Elsevier.
3. Sam Anahory, Dennis Murray, "Data Warehousing in the Real World : A Practical Guide for Building Decision Support Systems, 1ste", Pearson Education.

Online Resources

1. <https://archive.nptel.ac.in/courses/106/105/106105174/>
2. <http://www.digimat.in/nptel/courses/video/106105174/L01.html>

PO- PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1		2	1		2		1		1			1	1
CO2	1				1			2		1			1	1
CO3	1		1	1		1				1				1
CO4	2		1		2			2		1			2	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	4	Semester	VII		
Course Name	Distributed Data Base System				
Code	NBSCE3703				
Course Type	DSE3C	L	T	P	Credit
Pre-Requisite	Database Management Systems & Networking	3	1	-	4
Course Objectives	To understand the need for distributed database technology to tackle deficiencies of the centralized database systems, the concepts and techniques of distributed database including principles, architectures, design, implementation and major domain of application.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Analyze database with distributed database concepts and its structures.				
CO2	Apply the concepts of Distributed Transaction processing and concurrency control.				
CO3	Illustrate reliability and providing security in the distributed databases.				
CO4	Learn the concepts of Parallel Database Systems				
Module	Course Contents	Contact Hrs.	Mapped CO		
1	Introduction to distributed databases: What is DDBS? Advantages and Disadvantages of DDBS, comparison of distributed and centralized systems, DDBMS Architecture , global relations, fragment and physical image, types of schemas, methods of fragmentation of a relation, levels of transparency in a distributed system, integrity constraints ([1] Chapter 1, Chapter 2).	15	1		
2	Distributed Database Design: Alternative Design Strategies, Distributed Design Issues, Fragmentation, Data Allocation. Transaction Management: The Transaction Concept, Goal of Transaction Management, Characteristics of Transaction Management, Characteristics of Transaction s. Taxonomy of Transaction Model. Concurrency Control: Concurrency Control in Centralized Database Systems and DDBMS. Distributed Concurrency Control Algorithms, Deadlock Management ([1] Chapter 3).	15	2		

3	Semantic Data Control: View Management, Data Security, Semantic Integrity Control, Query Processing Issues: Objectives of Query Processing, Characteristics of Query Processors, Layer of Query Processing, Query Decomposition, Localization of Distributed Data. Distributed Query Optimization: Factors Governing Query Optimization, Centralized Query Optimization, Ordering of Fragment Queries, Distributed Query Optimization Algorithm. ([1] Chapter 5, Chapter 9).	15	3
4	Reliability: Reliability Issues in DDBSs, Types of Failures, Reliability Techniques, Commit Protocols, Recovery Protocols. Parallel Database Systems: Parallel architecture, Parallel Query Processing and Optimization, Load Balancing. Advance Topics: Mobile Database, Distributed Object Management, Multimedia Database ([1] Chapter 12-15).	15	4

Suggested Readings

1. Distributed Databases Principles and Systems by Stefano Ceri and GuiseppPelagatti, McGraw- Hill International Editions, 2004.
2. Distributed Database Systems by David Bell, JameGrimson, Addison-Wesley, 1992.
3. M.TamerOzsu, Patrick Valdureiz, 'Principles of Distributed Database Systems' Second Edition, Prentice Hall, 2002.

Online Resources

1. <https://nptel.ac.in/courses/106106168>
2. <https://www.digimat.in/nptel/courses/video/106106168/L01.html>

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1		2	1		2		1		1			1	1
CO2	1				1			2		1			1	1
CO3	1		1	1		1				1				1
CO4	2		1		2			2		1			2	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science					
Year	4	Semester			VII	
Course Name	Mobile Computing					
Code	NBSCE3704					
Course Type	DSE3D	L	T	P	Credit	
Pre-Requisite	Computer Networks, Distributed Systems / Distributed Operating Systems	3	1	-	4	
Course Objectives	To make the student understand the concept of mobile computing paradigm, its novel applications and limitations, the typical mobile networking infrastructure through a popular GSM protocol, the issues and solutions of various layers of mobile networks.					
Course Outcomes: Upon successful completion of syllabus, a student will be able to:						
CO1	Understand the concept of mobile computing paradigm, its novel applications and limitations.					
CO2	Analyze and develop new mobile applications					
CO3	Understand the protocols and platforms related to mobile environment					
CO4	Classify data delivery mechanisms					
Module	Course Contents			Contact Hrs.	Mapped CO	
1	Introduction: Mobile Communications, Mobile Computing – Paradigm, Promises/Novel Applications and Impediments and Architecture; Mobile and Handheld Devices, Limitations of Mobile and Handheld Devices. GSM – Services, System Architecture, Radio Interfaces, Protocols, Localization, Calling, Handover, Security, New Data Services, GPRS([1] Chapter 4).			15	1	
2	(Wireless) Medium Access Control (MAC): Motivation for a specialized MAC (Hidden and exposed terminals, Near and far terminals), SDMA, FDMA, TDMA, CDMA, Wireless			15	2	

	LAN/(IEEE 802.11) Mobile Network Layer: IP and Mobile IP Network Layers, Packet Delivery and Handover Management, Location Management, Registration, Tunneling and Encapsulation, Route Optimization, DHCP ([1] Chapter 3).		
3	Mobile Transport Layer: Conventional TCP/IP Protocols, Indirect TCP, Snooping TCP, Mobile TCP, Other Transport Layer Protocols for Mobile Networks. Database Issues: Database Hoarding & Caching Techniques, Client-Server Computing & Adaptation, Transactional Models, Query processing, Data Recovery Process & QoS Issues ([1] Chapter 9).	15	3
4	Mobile Ad hoc Networks (MANETs): Introduction, Applications & Challenges of a MANET, Routing, Classification of Routing Algorithms, Algorithms such as DSR, AODV, DSDV, Mobile Agents, Service Discovery. Protocols and Platforms for Mobile Computing: WAP, Bluetooth, XML, J2ME, JavaCard, Overview: PalmOS, Windows CE, SymbianOS, Linux for Mobile Devices, Android ([1] Chapter 8).	15	4

Suggested Readings

1. Raj Kamal, "Mobile Computing", Oxford University Press, 2007, ISBN: 0195686772
2. Asoke K Talukder, Hasan Ahmed, Roopa Yavagal Mobile Computing: Technology, Applications and Service Creation, McGraw Hill Education.
3. Dr. N.N. Jani, Dr. Ashish N. Jani, "Mobile Computing (Technologies & Applications)", S.Chand Publication.

Online Resources

1. <https://archive.nptel.ac.in/courses/106/106/106106147/>
2. <https://archive.nptel.ac.in/noc/courses/noc16/SEM2/noc16-cs13/>

PO- PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1					1		1			1		2	
CO2	2		1	2	2	1	2	2			2		1	1
CO3	1		2	2	2	2	2	1			1	2	1	1
CO4				2	2	2		2			1		1	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	4	Semester	VIII		
Course Name	Sentiment Analysis				
Code	NBSCE3801				
Course Type	DSE4A	L	T	P	Credit
Pre-Requisite	Natural language processing (NLP) and machine learning to identify and extract subjective information.	3	1	-	4
Course Objectives	To determine the feelings, opinions, emotions, among other things, of people on something or someone				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Understand key issues involved in the study of semantic fields and Explore the meanings of an expression in a systematic manner.				
CO2	Solve simple problems in semantic analysis and Explain the basic goals of several different approaches to semantics.				
CO3	Undertake guided research in topics in semantics and the relationship between syntax and semantics.				
CO4	Distinguish between semantics and pragmatics and relationship between words, concepts, and things /facts (sense, reference, extension/intension)				
Module	Course Contents			Conta ct Hrs.	Map ped CO
1	Introduction: Need for Sentiment Analysis, Problem of Sentiment Analysis Subjectivity, Stance, Words to Discourse, Pragmatics, Natural Language Processing Issues, Opinion Definition, Sentiment Analysis Tasks, Opinion Summarization, Types of Opinion Subjectivity and Emotion ([1] Chapter 1).			15	1
2	Sentiment Classification: Supervised Learning, Unsupervised Learning Rating Prediction, Cross-Domain Sentiment Classification, Cross Language Sentiment Classification, Sentence Subjectivity And Classification. Subjectivity Classification, Sentence Sentiment Classification, Conditional Sentences, Sarcastic Sentences, Cross, Language Subjectivity and Sentiment Classification – Discourse Information for Sentiment Classification ([1] Chapter 3).			15	2

3	Aspect Based Sentiment Analysis: Aspect sentiment classification, Basic rules of opinions and Compositional Semantics, Aspect Extraction, Identifying Resource usage aspect, Simultaneous Opinion Lexicon Expansion and Aspect Extraction, Grouping aspects into categories, Entity, Opinion Hold and Timing Extraction, Co-reference Resolution and Word Sense Disambiguation Aspect and Entity Extraction ([1] Chapter 5).	15	3
4	Opinion Summarization & Tools for Sentiment Analysis: Aspect Based Opinion Summarization, Contrastive view Summarization Traditional Summarization, Analysis of Comparative Opinions Identifying Comparative Sentences, Identifying Preferred Entities, Opinion Search and Retrieval, Opinion Spam Detection Types of Spam Detection, Supervised and Unsupervised Approach, Group Spam Detection. Detecting Fake or Deceptive Opinions, Quality of Review, Quality as Regression Model ([1] Chapter 7-9).	15	4

Suggested Readings

1. Bo Pang and Lillian Lee, Opinion Mining and Sentiment Analysis: Now Publishers Inc., 2008.
2. Roy De Groot, Data mining for Tweet sentiment classification – Twitter sentiment, 2009.
3. Erik Cambria, Dipankar Das, A Practical Guide to Sentiment Analysis, Springer, 2017.

Online Resources

1. <https://hits.digimat.in/nptel/courses/video/106105158/L61.html>
2. <https://nptel.ac.in/courses/106101224>

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1				1	1			1		1	1
CO2	1	1	1			1	1	1			1		1	1
CO3	1	1	1			1	1	2			2		1	1
CO4	1	1	1			2	1	2			2		1	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	4	Semester		VIII	
Course Name	Augmented & Virtual Reality				
Code	NBSCE3802				
Course Type	DSE4B	L	T	P	Credit
Pre-Requisite	Familiar with different computer programming languages as well as Concepts image processing tools.	3	1	-	4
Course Objectives	To gain the knowledge of historical and modern overviews and perspectives on virtual reality and the fundamentals 3D Interface, Software Technologies and the technical aspects of augmented and virtual reality systems.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Understand Historical Overview, Current Trends and Future applications of Immersive Technologies.				
CO2	Understand Overview of human physiology.				
CO3	Understand the usability factors.				
CO4	Understand 3D interactive and procedural graphics.				
Module	Course Contents	Contact Hrs.		Mapped CO	
1	Introduction: A Brief History of Virtual Reality, The five Classic Components of a VR System, Basic features of VR systems, Architecture of VR systems, Early Commercial VR Technology Hardware Technologies For 3d User Interfaces: Visual Displays, Auditory Displays, Haptic Displays, Choosing Output Devices for 3D User Interfaces ([3] Chapter 1).	15		1	
2	3D User Interfaces: Why 3D user interfaces, Major use tasks in VE, Interaction techniques for selection manipulation and navigation, 3D UI evaluation, Virtual Reality Applications: Engineering, Architecture Education, Medicine, Entertainment, Science, Training ([3] Chapter 2).	15		2	

3	Software Technologies: Database - World Space, World Coordinate, World Environment, Objects - Geometry, Position / Orientation, Hierarchy, Bounding Volume, Scripts and other attributes, VR Environment - VR Database, Tessellated Data, LODs, Cullers and Occluders, Lights and Cameras, Scripts, Interaction - Simple, Feedback, Graphical User Interface, Control Panel, 2D Controls, Hardware Controls, Room / Stage / Area Descriptions, World Authoring and Playback, VR toolkits, Available software in the market ([3] Chapter 3-4).	15	3
4	Augmented and Mixed Reality, Taxonomy, technology and features of augmented reality, difference between AR and VR, Challenges with AR, AR systems and functionality, Augmented reality methods, visualization techniques for augmented reality ([3] Chapter 7-9).	15	4

Suggested Readings

1. AlanBCraig,WilliamR ShermanandJeffreyDWill,“DevelopingVirtualRealityApplications:FoundationsofEffectiveDesign”,MorganKaufmann,2009.
2. DougABowman,ErnestKuijff,JosephJLaViola,JrandIvanPoupyrev,“3DUserInterfaces,TheoryandPractice”.
3. Burdea,GrigoreCandPhilippeCoiffet,“VirtualRealityTechnology”,WileyInterscience,India,2003.

Online Resources

1. <https://archive.nptel.ac.in/courses/121/106/121106013/>
2. https://onlinecourses.swayam2.ac.in/nou23_ge34/preview

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1							2			2		1	1
CO2	1					1		1			1		1	1
CO3	1					1		1			1		1	1
CO4	1							2			1		1	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science				
Year	4	Semester	VIII		
Course Name	Neural Networks				
Code	NBSCE3803				
Course Type	DSE4C	L	T	P	Credit
Pre-Requisite	Concept of Artificial Intelligence and Computer Network	3	1	-	4
Course Objectives	To understand the biological neural network model equivalent neuron models, the architecture, learning algorithm, perceptron and Back propagation algorithms.				
Course Outcomes: Upon successful completion of syllabus, a student will be able to:					
CO1	Create different neural networks of various architectures both feed forward and feed backward.				
CO2	Perform the testing of neural networks and do the perform analysis of these networks for various pattern recognition applications.				
CO3	Understand the impact of environment and propose the technological solutions for sustainable development.				
CO4	Use current techniques, skills, and IT tools necessary for computing practice.				
Module	Course Contents	Contact Hrs.	Mapped CO		
1	Introduction: Neural Network, Human Brain, Models of a Neuron, Neural Networks viewed as Directed Graphs, Network Architectures, Knowledge Representation, Artificial Intelligence and Neural Networks, Error Correction Learning, Memory Based Learning. ([1] Chapter 1).	15	1		
2	Perceptron: Adaptive Filtering Problem, Unconstrained Organization Techniques, Linear Least Square Filters, Least Mean Square Algorithm, Learning Curves, Learning Rate Annealing Techniques Perceptron: Back Propagation Algorithm, Heuristics, Output Representation and Decision Rule, Feature Detection, Hebbian Rule.([1] Chapter 1).	15	2		
3	Back Propagation: Back Propagation and Differentiation, Hessian Matrix, Generalization, Cross Validation, Network Pruning Techniques, Virtues, and Limitations of Back Propagation Learning, Accelerated Convergence, Supervised Learning ([1] Chapter 4)	15	3		

4	Neuro Dynamics: Dynamical Systems, Stability of Equilibrium States, Attractors, Neuro Dynamical Models, Manipulation of Attractors as a Recurrent Network Paradigm Hopfield Models.([1] Chapter 13).	15	4
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Suggested Readings

1. Neural Networks A Comprehensive Foundations, Simon Haykin, PHI Edition, 2004.
2. Artificial Neural Networks-B. Yegnanarayana, Prentice Hall of India P. Ltd, 2005.
3. Neural Networks in Computer Intelligence, Li MinFu, TMH, 2003.

Online Resources

1. <https://nptel.ac.in/courses/117105084>
2. <https://archive.nptel.ac.in/courses/108/108/108108148/>

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	1	1	1				1	1			1		1	1
CO2	1	1	1			1	1	1			1		1	1
CO3	1	1	1			1	1	2			2		1	1
CO4	1	1	1			2	1	2			2		1	1

Program	B.Sc. (Hons./ Hons. with research) Computer Science					
Year	4	Semester			VIII	
Course Name	Expert System					
Code	NBSCE3804					
Course Type	DSE4D	L	T	P	Credit	
Pre-Requisite	Knowledge of Artificial Intelligence.	3	1	-	4	
Course Objectives	To rebuilding human reasoning on the expertise obtained from experts, stores knowledge, establishes links between knowledge and ability to perform human intellectual activities.					
Course Outcomes: Upon successful completion of syllabus, a student will be able to:						
CO1	Apply the basic techniques of artificial intelligence.					
CO2	Discuss the architecture of an expert system and its tools.					
CO3	Understand the importance of building expert systems.					
CO4	Understand various problems with expert systems.					
Module	Course Contents				Contact Hrs.	Mappe d CO
1	Introduction to Expert Systems: Architecture of expert systems, Representation and organization of knowledge, Basics characteristics, and types of problems handled by expert systems.([1] Chapter 20).				15	1
2	Expert System Tools: Techniques of knowledge representations in expert systems, knowledge engineering, system-building aids, support facilities, stages in the development of expert systems.([1] Chapter 20).				15	2
3	Building an Expert System: Expert system development, Selection of the tool, Acquiring Knowledge, Building process.([2] Chapter 16).				15	3

4	Problems with Expert Systems: Difficulties, common pitfalls in planning, dealing with domain experts, difficulties during development.([2] Chapter 16).	15	4
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Suggested Readings

1. Patterson, Artificial Intelligence & Expert System, Prentice Hall India, 1999.
2. Hayes-Roth, Lenat, and Waterman: Building Expert Systems, Addison Wesley.
3. Weiss S.M. and Kulikowski C.A., “A Practical Guide to Designing Expert Systems”, Rowman & Allanheld, New Jerse.

Online Resources

1. <http://www.digimat.in/nptel/courses/video/106105077/L25.html>
2. <http://acl.digimat.in/nptel/courses/video/127105006/L38.html>

PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1			1	1		1					1	1
CO2	2	1	1	1	1								1	1
CO3	2	1	2	1	1			1					1	1
CO4	2	1	2	1	1	1		2			1		1	1