Course Code	Name of Course	Course Category	Teaching Scheme				Credits	Evaluation Scheme					
								Theory			Practical		Total Marks
			L	T	P	Total Hours		TAE	CAE	ESE	INT	EXT	
SEMESTER-III													
23BTSHL201 CS	Discrete Mathematics and Graph Theory	PCC2	3	1		4	4	10	15	50			75
23BTCSL201/ 23BTCSP201	Data Structure and Algorithms	PCC3	3		2	5	4	10	15	50	25	25	125
UNXXL2XX	Multi-Disciplinary Minor-I	MD M1	2			2	2	10	15	50			75
23BTCSL211	Open elective –I: Introduction To Blockchain Technology	OE1	4			4	4	10	15	50			75
23BTMBL201	Engineering Economics and Industrial Management	EEMC1	2			2	2	10	15	50			75
UNHUL20X	Humanities Elective	VEC1	2			2	2	10	15	50			75
23BTCSP205	Minor Project	CEP			4	4	2				25	25	50
TOTAL			**16**	**1**	**6**	**23**	**20**	**60**	**90**	**300**	**50**	**50**	**550**

Course Title: **Data Structure and Algorithms**										
Semester	III	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	ODD	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	C	3	--	2	4	10	15	50	25	25
Course Code	23BTCSL201/ 23BTCSP201									
Teaching Mode	Online	5			Total	75			50	
Duration of ESE						125				

Course Objectives	This course introduces basic idea of data structure while making aware of methods and structure used to organize large amount of data.
	It's also aimed at developing skill to implement methods to solve specific problems using basic data structures.
	The course also provides career opportunities in design of data, implementation of data, technique to sort and searching the data.
Course Outcomes	CO1: Analyze various techniques for searching, Sorting and Hashing.
	CO2: Illustrate linear arrays and linked lists, including operations such as insertion, deletion, traversal, sorting, and searching.
	CO3: Demonstrate the array and linked representations of stacks and queues and their applications.
	CO4: Apply trees as non-linear data structure to find solution for given engineering applications.
	CO5: Understand the basics of Graphs as non-linear data structures.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes	Program Outcomes and Program Specific Outcomes													
	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
CO1		3	2	3									1	
CO2		2	3	3									2	
CO3		3	3	3									2	1
CO4		3	3	3									3	2
CO5		3	3	2									3	1

Course Contents:

Unit	Contents	Hours
I	Introduction to Algorithms, Searching and Sorting Introduction to Algorithms, Common operations on data structures, Types of data structures, Abstract Data Type Time and Space Complexity, Step Count Method, Asymptotic Notations. Searching: Linear Search, Binary Search Sorting: Bubble sort, Selection Sort, Merge-Sort, Shell Sort, Radix Sort, Introduction to Hashing	9
II	Arrays and Linked Lists Arrays: Introduction, Linear Arrays, Arrays as ADT, Representation of Linear array in Memory, Traversing Linear Arrays, Insertion and deletion in arrays. Linked List: Introduction, Representation of Linked Lists in Memory, Traversing a Linked List, Searching a Linked List, Memory Allocation; Garbage Collection, Types of linked lists, Insertion and Deletion in Singly Linked List, Insertion and Deletion in Doubly Linked List, Insertion and Deletion in Circular Linked List	9
III	Stacks, Queue and Recursion Stacks-Introduction to Stacks ,Array Representation of Stacks ,Linked Representation of Stacks, Stack as ADT, Various operations on stacks using arrays and linked lists, Application of Stacks : Polish Notations, Recursion, Towers of Hanoi Queue: Introduction to Queues, Array Representation of Queues, Linked Representation of Queues, Queues as ADT, Circular Queues, Deques, Priority Queues, Applications of Queues	9
IV	Trees and Binary Trees General and Binary Trees, Representation of binary tree in memory, Operations on Binary Trees, Binary Tree Traversals, Threaded Binary Trees, Binary Search Trees ,various operations in Binary Search Trees, AVL Search Trees, Insertion in an AVL Search Tree, Deletion in an AVL Search Tree, m-way Search Trees, B-Trees-Insertion and deletion in B-Tree, B+Trees-Insertion and deletion in B+Tree	10
V	Graphs and their Applications: Introduction, Graph Theory Terminology, Representation of Graphs, Operations on Graphs, Traversing a Graph, Posets , Topological Sorting, Spanning Trees, Minimum Spanning Trees	8

Text Books	1.	AVAho, J Hopcroft, JD Ullman, Data Structures and Algorithms, Addison-Wesley, 1983.
	2.	THCormen, CF Leiserson, RL Rivest, C Stein, Introduction to Algorithms, 3rd Ed., MIT Press, 2009.
	3.	Sahni, S., "Data Structures, Algorithms, and Applications in C++", WCB/McGraw-Hill.
E--Books	1.	https://apps2.mdp.ac.id/perpustakaan/ebook/Karya%20Umum/Dsa.pdf
Reference Books	1.	Data Structures & Algorithms, 1e, Alfred V.Aho, Jeffery D. Ullman , Person.

	2.	MT Goodrich, R Tamassia, DM Mount, Data Structures and Algorithms in Java, 5th Ed., Wiley, 2010. (Equivalent book in C also exists.)
	3.	Wirth, N., "Algorithms and Data Structures", Prentice-Hall of India.
On-line TL Material	1.	https://nptel.ac.in/courses/106/102/106102064/
	2.	http://cse01-iiith.vlabs.ac.in/
	3.	https://ds2-iiith.vlabs.ac.in/data-structures-2/

Course Title: Introduction to Blockchain Technology open elective -I										
Semester	III	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	ODD	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	C	4		-	4	10	15	50	-	
Course Code	23BTCSL211									

Course Objectives	The student should be made to:
	1. Understand the technical aspects of crypto currencies and block chain technologies.
	2. Understand fundamental concepts of the cryptographic concepts
	3. Understand fundamental concepts of the cryptocurrencies.
	4. Understand the concepts of cryptocurrency regulations.
Course Outcomes	At the end of the course, the student should be able to
	CO1: Describe the basic concepts and technology used for blockchain.
	CO2: Analyse the primitives of the distributed computing and cryptography related to blockchain.
	CO3: Illustrate the concepts of Bitcoin and their usage.
	CO4: Implement Ethereum block chain contract.
	CO5: Apply security features in blockchain technologies.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	3	-	-	-	-	-	-	-	2	1	3	1
CO2	2	3	-	3	1	-	-	-	-	-	-	3	1	3	2
CO3	3	-	-	2	1	-	-	-	-	-	-	2	1	3	1
CO4	2	3	-	2	1	-	-	-	-	-	-	3	1	1	2
CO5	3	-	-	2	-	-	-	-	-	-	-	2	1	1	3

Course Contents:

Unit	Contents	Hours
I	**Introduction:** Need for Distributed Record Keeping, Byzantine Generals problem, Why Nakamoto Came up with Blockchain based cryptocurrency? , Consensus, Consensus Algorithm, Peer to peer network , byzantine fault-tolerant distributed computing, Byzantine Models of fault tolerance .	7
II	**Cryptographic Fundamentals:** Cryptographic basics for crypto currency - a short overview of Hashing, cryptographic algorithm – SHA 256,signature schemes, encryption schemes and elliptic curve cryptography- Introduction to Hyperledger- Hyperledger framework - Public and Private Ledgers.	8
III	**Bitcoin** Bitcoin –Wallet-Block, Merkle tree, Bitcoin blockchain, the challenges, and solutions, proof of work, Proof of stake, alternatives to Bitcoin consensus, Bitcoin scripting language and their uses.	6
IV	**Ethereum** Ethereum_ Ethereum Virtual Machine (EVM) - Construction, DAO, Smart Contract, GHOST, Vulnerability, Attacks, Sidechain, Namecoin, comparing Bitcoin scripting vs. Ethereum Smart Contracts	8
V	**Cryptocurrency Regulation :**Stakeholders, Roots of Bit coin, Legal Aspects- Crypto currency Exchange, Black Market and Global Economy. **Privacy, Security issues in Blockchain** :seudo-anonymity vs. anonymity, Zcash and Zk-SNARKS for anonymity preservation, attacks on Blockchains – such as Sybil attacks, selfish mining	8

Text Books	1.	Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller and Steven Goldfeder, Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction, Princeton University Press (July 19, 2016).
	2.	Anshul Kaushik, “Block Chain and Crypto Currencies”, Khanna Publishing House, Delhi
Reference Books	1.	Antonopoulos, Mastering Bitcoin: Unlocking Digital Cryptocurrencies
	2.	Satoshi Nakamoto, Bitcoin: A Peer-to-Peer Electronic Cash System
	3.	DR. Gavin Wood, “ETHEREUM: A Secure Decentralized Transaction Ledger,”Yellow Paper 2014
	4	Nicola Atzei, Massimo Bartoletti, and Tiziana Cimoli, A survey of attacks on Ethereum ,smart contracts
	5	Josh Thompson, ‘Blockchain: The Blockchain for Beginnings, Guild to Blockchain Technology and Blockchain Programming’, Create Space Independent Publishing Platform, 2017.
	1.	Prof. Sandeep Shukla, IIT Kanpur

On-line TL Material		https://nptel.ac.in/courses/106/104/106104220/
	2.	Prof. Praveen Jayachandran, IIT Kharagpur https://nptel.ac.in/courses/106/105/106105184/

Title: **Computer Architecture and Organization**										
Semester	III	Course Title: Computer Architecture and Organization								
Term	Odd	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Course Category	PCC8	Th	Tu	Pr	Credits	TAE	CAE	ESE	Int	Ext
Course Code	23BTCSL203	4	-	-	4	10	15	50	-	-
Teaching Mode	Offline									

Course Objectives	To understand the design principles of digital computing systems
	To provide an essential understanding of different subsystems of modern computer system and design aspects of these subsystems3
	To provide an overview of performance enhancement methods in instruction Execution
Course Outcomes	CO1: To describe the basic components and design of a computer system
	CO2: To examine the issues involved in the instruction execution and various stages of instruction life stage
	CO3: To apply the concept of various memories and interfacing technologies
	CO4: To analyze the different parallel processing technique
	CO5: To design different high-performance computing architecture

Mapping of Course Outcomes with Program Outcomes and Program-Specific Outcomes:

Course Outcomes	Program Outcomes and Program Specific Outcomes														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
CO1	3												3		
CO2		3											2		
CO3		3											2		
CO4			3										3		
CO5			3											3	

Course Contents:

Unit	Contents	Hours
I	Basic functional blocks of a computer: CPU, memory, input-output subsystems, control unit. Instruction set architecture of a CPU –registers, instruction execution cycle, RTL interpretation of instructions, addressing modes, instruction set, Instruction set architecture CISC, RISC, Case study: Instruction sets of common CPUs	8
II	Data representation method, IEEE standard: single and double precision format and examples, Fixed point Addition, Subtraction, Multiplication, and Division. Floating Point Arithmetic, High-performance arithmetic. Booth's algorithm: Multiplication & Division	8
III	Memory hierarchy, Memory Chip Organization, Cache memory, and Virtual memory. Parallel Bus Architectures, Internal Communication Methodologies, DMA, Serial Bus Architectures, Mass storage, Input and Output Devices, Segmentation, TLB	8
IV	An Overview of Pipelining: Basic concepts of Pipelining, Pipelined Datapath, and Control. Data Hazards: Forwarding versus Stalling, Control Hazards, Exceptions, Arithmetic and Instruction Pipeline, throughput and speedup, pipeline hazards.	8
V	CPU control unit design: hardwired and micro-programmed design approaches, Case study: Von Neumann Architecture, Design of a simple hypothetical CPU, Multicore processors architecture, Simple MIPS Processor Components, Designing a Datapath for a Simple Processor	8

Text Books	1.	Computer Organization and Architecture by Carl Hamacher 4th Edition
	2.	Advance computer Architecture by Kai Hwang under Tata McGraw Hill Publications
	3.	Introduction to Parallel Processing: Algorithms & Architectures, Behrooz Parhami in Springer Shop
EBooks	1.	Computer Architecture and Organization by William Stalling http://home.ustc.edu.cn/~leedsong/reference_books_tools/Computer%20Organization%20and%20Architecture%2010th%20-%20William%20Stallings.pdf
Reference Books	1.	Introduction to Parallel Processing by P. Ravi Prakash, M. Sasikumar, Dinesh Shikhare By PHI Publications
	2.	Fundamentals of Parallel Processing by Jordan Harry, Alaghband Gita, PHI Publication
	3	Parallel Computers – Architecture and Programming by V. Rajaraman And C. Siva Ram Murthy.
	4.	Introduction to Parallel Programming by Steven Brawer
On-line TL Material	1.	NPTL https://nptel.ac.in/courses/106/105/106105163/

Course Title: Computer Architecture MD-I										
Semester	III	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	ODD	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	Core	2 Hrs.	- -	--	2	10	15	50	--	--
Course Code	23BTCSL208									
Teaching Mode	Offline	2 Hrs			Total	75			-	
Duration of ESE	2 Hrs.					75				

Course Objectives	To understand the design principles of digital computing systems
	To provide essential understanding of different subsystems of modern computer system and design aspects these subsystems3
	To provide overview on performance enhancement methods in instruction execution
Course Outcomes	Upon successful completion of this course, student will be able to:
	CO1: To describe the basic components and design of a computer system
	CO2: To examine the issues involved in the instruction execution and various stages of instruction life stage
	CO3: To apply the concept of various memories and interfacing technologies
	CO4: To analyze the different parallel processing technique
	CO5: To design different high performance computing architecture

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcomes	Program Outcomes and Program Specific Outcomes													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO0	PO1	PO2	PSO1	PSO2
CO1	1	--	--	--	--	--	--	--	--	--	--	--	3	--
CO2	--	2	--	--	--	--	--	--	--	--	--	--	2	--
CO3	--	3	--	--	--	--	--	--	--	--	--	--	2	--
CO4	--	--	3	--	--	--	--	--	--	--	--	--	3	--
CO5	--	--	3	--	--	--	--	--	--	--	--	--	--	3

Course Contents:

Unit	Contents	Hours
I	**Introduction:** Overview and history of computer architecture, CPU, memory, input-output subsystems, control unit. Instruction set architecture of a CPU:–registers, instruction execution cycle, RTL interpretation of instructions, addressing modes, Instruction set architecture CISC, RISC. **Case study:** –instruction sets of common CPUs, performance matrices for calculation of processingin Computer	5
II	**Computer Arithmetic:** Fixed point Addition, Subtraction, Multiplication and Division. Floating Point Arithmetic, High-performance arithmetic, Booth's algorithm: Division and Multiplication, Data representation methods. **IEEE standard:** single and double precision format and examples, ALU	5
III	**Memory Architecture:** Memory hierarchy, Memory Chip Organization, Cache memory, Virtual memory, Parallel Bus Architectures, Internal Communication Methodologies, Serial Bus Architectures, Mass storage, Input and Output Devices, Segmentation, TLB, DMA	5
IV	**An Overview of Pipelining:** Basic concepts of Pipelining, Pipelined Datapath, and Control. **Data Hazards:** Forwarding versus Stalling, Control Hazards, Exceptions, Arithmetic and Instruction Pipeline, throughput and speedup, pipeline hazards.	5
V	**Processor Architecture:** hardwired and micro-programmed design approaches, Case study - design of a simple hypothetical CPU. Multicore processors architecture, Introduction toGraphics Processing Units, Clusters and Warehouse scale computers, Advanced topics & its application.	5

Text Books	1.	Computer Organization and Architecture by Carl Hamacher 4th Edition
	2.	Advance computer Architecture by Kai Hwang under Tata McGraw Hill Publications
	3.	Introduction to Parallel Processing: Algorithms & Architectures, Behrooz Parhami in Springer Shop
EBooks	1.	Computer Architecture and Organization by William Stalling http://home.ustc.edu.cn/~leedsong/reference_books_tools/Computer%20Organization%20and%20Architecture%2010th%20-%20William%20Stallings.pdf
Reference Books	1.	Introduction to Parallel Processing by P. Ravi Prakash, M. Sasikumar, Dinesh Shikhare By PHI Publications
	2.	Fundamentals of Parallel Processing by Jordan Harry, Alaghband Gita, PHI Publication
	3	Parallel Computers – Architecture and Programming by V. Rajaraman And C. Siva Ram Murthy.
	4.	Introduction to Parallel Programming by Steven Brawer
On-line TL Material	1.	NPTL https://nptel.ac.in/courses/106/105/106105163/

Course Title: Introduction to Blockchain Technology										
Semester	III	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	ODD	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	C	4		-	4	10	15	50	-	
Course Code	23BTCSL211									

Course Objectives	The student should be made to:
	1. Understand the technical aspects of crypto currencies and block chain technologies.
	2. Understand fundamental concepts of the cryptographic concepts
	3. Understand fundamental concepts of the cryptocurrencies.
	4. Understand the concepts of cryptocurrency regulations.
Course Outcomes	At the end of the course, the student should be able to
	CO1: Describe the basic concepts and technology used for blockchain.
	CO2: Analyse the primitives of the distributed computing and cryptography related to blockchain.
	CO3: Illustrate the concepts of Bitcoin and their usage.
	CO4: Implement Ethereum block chain contract.
	CO5: Apply security features in blockchain technologies.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	3	-	-	-	-	-	-	-	2	1	3	1
CO2	2	3	-	3	1	-	-	-	-	-	-	3	1	3	2
CO3	3	-	-	2	1	-	-	-	-	-	-	2	1	3	1
CO4	2	3	-	2	1	-	-	-	-	-	-	3	1	1	2
CO5	3	-	-	2	-	-	-	-	-	-	-	2	1	1	3

Course Contents:

Unit	Contents	Hours
I	**Introduction:** Need for Distributed Record Keeping, Byzantine Generals problem, Why Nakamoto Came up with Blockchain based cryptocurrency? , Consensus, Consensus Algorithm, Peer to peer network , byzantine fault-tolerant distributed computing, Byzantine Models of fault tolerance .	7
II	**Cryptographic Fundamentals:** Cryptographic basics for crypto currency - a short overview of Hashing, cryptographic algorithm – SHA 256,signature schemes, encryption schemes and elliptic curve cryptography- Introduction to Hyperledger- Hyperledger framework - Public and Private Ledgers.	8
III	**Bitcoin** Bitcoin –Wallet-Block, Merkle tree, Bitcoin blockchain, the challenges, and solutions, proof of work, Proof of stake, alternatives to Bitcoin consensus, Bitcoin scripting language and their uses.	6
IV	**Ethereum** Ethereum_ Ethereum Virtual Machine (EVM) - Construction, DAO, Smart Contract, GHOST, Vulnerability, Attacks, Sidechain, Namecoin, comparing Bitcoin scripting vs. Ethereum Smart Contracts	8
V	**Cryptocurrency Regulation :** Stakeholders, Roots of Bit coin, Legal Aspects-Crypto currency Exchange, Black Market and Global Economy. **Privacy, Security issues in Blockchain** : seudo-anonymity vs. anonymity, Zcash and Zk-SNARKS for anonymity preservation, attacks on Blockchains – such as Sybil attacks, selfish mining	8

Text Books	1.	Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller and Steven Goldfeder, Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction, Princeton University Press (July 19, 2016).
	2.	Anshul Kaushik, "Block Chain and Crypto Currencies", Khanna Publishing House, Delhi
Reference Books On-line TL Material	1.	Antonopoulos, Mastering Bitcoin: Unlocking Digital Cryptocurrencies
	2.	Satoshi Nakamoto, Bitcoin: A Peer-to-Peer Electronic Cash System
	3.	DR. Gavin Wood, "ETHEREUM: A Secure Decentralized Transaction Ledger,"Yellow Paper 2014
	4	Nicola Atzei, Massimo Bartoletti, and Tiziana Cimoli, A survey of attacks on Ethereum ,smart contracts

	5	Josh Thompson, 'Blockchain: The Blockchain for Beginnings, Guild to Blockchain Technology and Blockchain Programming', Create Space Independent Publishing Platform, 2017.
On-line TL Material	1.	Prof. Sandeep Shukla, IIT Kanpur https://nptel.ac.in/courses/106/104/106104220/
	2.	Prof. Praveen Jayachandran, IIT Kharagpur https://nptel.ac.in/courses/106/105/106105184/