Department of Computer Science & Engineering

Bachelor of Technology

Semester-wise Course Structure (From 2019 onwards)

SEMESTER - 1							
Course Code	**Course Title**	**Course Type**	**Contact Hours**			**Credit**	**Pre-requisites**
			L	**T**	**P**	**C**	
MA 101	Differential Calculus and Linear Algebra	Sc/HS	3	1	0	4	None
ME 101	Engineering Mechanics	BE	3	0	0	3	None
CY101/ PH101	Chemistry/Physics	Sc/HS	2/3	1	0	3/4	None
CE 101	Engineering Drawing	BE	1	0	4	3	None
EE101/ EC101	Basic Electrical Engineering /Basic Electronics Engineering	BE	2	0	0	2	None
HS 101	English Language Skills	Sc/HS	2	0	0	2	None
HS 151	English Language Skills Lab	L	0	0	2	1	None
CY151/ PH151	Chemistry Lab /Physics Lab	L	0	0	2	1	None
EE151/ EC151	Basic Electrical Lab /Basic Electronics Lab	L	0	0	2	1	None
Total Contact Hours – Component wise			**13/ 14**	**2**	**10**	---	
Total Contact Hours			**25/26**			**20/21**	---

SEMESTER – 2							
Course Code	**Course Title**	**Course Type**	**Contact Hours**			**Credit**	**Pre-requisites**
			L	**T**	**P**	**C**	
MA 102	Integral Calculus and Complex Variables	Sc/HS	3	1	0	4	None
EE101/ EC101	Basic Electrical Engineering /Basic Electronics Engineering	BE	2	0	0	2	None
PH101/ CY101	Physics/Chemistry	Sc/HS	3/2	1	0	4/3	None
CY 102	Environmental Science	Sc/HS	2	0	0	2	None
CS 102	Introduction to Computing	BE	2	1	0	3	None
ME 152	Workshop Practice	L	0	0	4	2	None
EE151/ EC151	Basic Electrical Lab/ Basic Electronics Lab	L	0	0	2	1	None
CY151/ PH151	Chemistry Lab /Physics Lab	L	0	0	2	1	None
CS 152	Computing Lab	L	0	0	2	1	None
Total Contact Hours – Component wise			**12/ 11**	**3**	**10**	---	
Total Contact Hours			**25/24**			**20/19**	---

SEMESTER - 3							
Course Code	Course Title	Course Type	Contact Hours			Credit	Pre-requisites
			L	T	P	C	
MA 201	Integral Transforms and PDEs	M	3	1	0	4	None
Professional Core Courses - 1, 2, 3							
CS 201	Data Structures	PC	3	0	0	3	None
CS 203	Digital Logic Design	PC	3	1	0	4	None
CS 205	Discrete Mathematical Structures	PC	3	1	0	4	None
Special Course – 1							
ME 291	Safety Engineering	S	2	0	0	2	None
Lab Courses - 1, 2, 3							
CS 251	Data Structures Lab	L	0	1	2	2	None
CS 253	Digital Logic Design Lab	L	0	1	2	2	None
CS 255	Internet Web Technology Lab	L	0	0	2	1	None
Total Contact Hours – Component wise			**14**	**5**	**6**	---	
Total Contact Hours			**25**			**22**	---

SEMESTER – 4							
Course Code	Course Title	Course Type	Contact Hours			Credit	Pre-requisites
			L	T	P	C	
Professional Core Courses - 4, 5, 6							
CS 202	Computer Organization	PC	3	1	0	4	CS 203
CS 204	Object Oriented Programming and Design	PC	3	1	0	4	CS 101
CS 206	Data Communication	PC	3	0	0	3	None
Professional Elective – 1							
CS 212	Analysis and Design of Algorithms	PE	3	0	0	3	None
CS 214	Computational Models for Real Time Systems	PE	3	0	0	3	None
CS 216	Cyber Physical Systems	PE	3	0	0	3	None
CS 218	Computer Arithmetic	PE	3	0	0	3	None
Professional Elective – 2							
CS 220	Principles of Programming Languages	PE	3	0	0	3	CS 101
CS 222	Programming in Java	PE	3	0	0	3	CS 101
CS 224	GUI Design and Programming	PE	3	0	0	3	CS 101
CS 226	Python Programming	PE	3	0	0	3	CS 101

Open Elective – 1							
CS 272	Object Oriented Programming	OE	2	0	0	2	CS 101
Lab Courses - 4, 5,6							
CS 252	Computer Organization Lab	L	0	0	2	1	CS 203
CS 254	Object Oriented Programming and Design Lab	L	0	1	2	2	CS 101
CS 256	Data Communication Lab	L	0	1	2	2	None
Total Contact Hours – Component wise			**17**	**4**	**6**	---	
Total Contact Hours			**27**			**24**	---

SEMESTER – 5

Course Code	Course Title	Course Type	Contact Hours			Credit	Pre-requisites
			L	T	P	C	
Professional Core Courses - 7, 8, 9							
CS 301	Operating Systems	PC	3	1	0	4	CS 204
CS 303	Database Management Systems	PC	3	1	0	4	CS 201
CS 305	Computer Networks	PC	3	0	0	3	None
Professional Elective – 3							
CS 311	Microprocessors and Interfacing	PE	3	1	0	4	None
CS 313	Embedded Systems	PE	3	1	0	4	None
CS 315	E-commerce and Cyber Laws	PE	3	1	0	4	None
CS 317	Machine Vision	PE	3	1	0	4	None
Professional Elective – 4							
CS 319	Automata and Formal Language	PE	3	0	0	3	None
CS 321	Formal Verification	PE	3	0	0	3	None
CS 323	Computational Geometry	PE	3	0	0	3	None
CS 325	Modern Digital Arithmetic	PE	3	0	0	3	None
Open Elective – 2							
CS 371	Database System Concepts	OE	2	0	0	2	None
Lab Courses - 7, 8, 9							
CS 351	Operating Systems Lab	L	0	1	2	2	CS 204
CS 353	Database Management Systems Lab	L	0	1	2	2	CS 201
CS 355	Computer Networks Lab	L	0	0	2	1	None
Total Contact Hours – Component wise			**17**	**5**	**6**	---	
Total Contact Hours			**28**			**25**	---

SEMESTER – 6							
Course Code	Course Title	Course Type	Contact Hours			Credit	Pre-requisites
			L	T	P	C	
Professional Core Courses – 10, 11							
CS 302	Software Engineering	PC	3	1	0	4	None
CS 304	Compiler Design	PC	3	1	0	4	None
Professional Elective – 5							
CS 312	Computer Graphics	PE	3	0	0	3	None
CS 314	Shell Programming	PE	3	0	0	3	None
CS 316	Augmented and Virtual Reality	PE	3	0	0	3	None
CS 318	Information Theory and Coding	PE	3	0	0	3	None
Professional Elective – 6							
CS 320	Machine Learning	PE	3	0	0	3	None
CS 322	Cryptography And Network Security	PE	3	0	0	3	None
CS 324	Data Analysis and Visualization	PE	3	0	0	3	None
CS 326	Multimedia	PE	3	0	0	3	None
CS 328	System Software	PE	3	0	0	3	None
Open Elective – 3							
CS 372	Introduction to Machine Learning	OE	2	0	0	2	None
Special HS Course – 2							
HS 392	Corporate Communication	S	2	0	0	2	None
Lab Courses – 10, 11							
CS 352	Software Engineering Lab	L	0	1	2	2	None
CS 354	Compiler Design Lab	L	0	1	2	2	None
CS 382	Term Paper	T	0	0	2	1	None
Total Contact Hours – Component wise			**16**	**4**	**6**	---	
Total Contact Hours			**26**			**23**	---

SEMESTER – 7							
Course Code	Course Title	Course Type	Contact Hours			Credit	Pre-requisites
			L	T	P	C	
CS 401	Project – I	P	0	0	10	5	None
Professional Elective –7							
CS 411	Soft Computing	PE	3	0	0	3	None

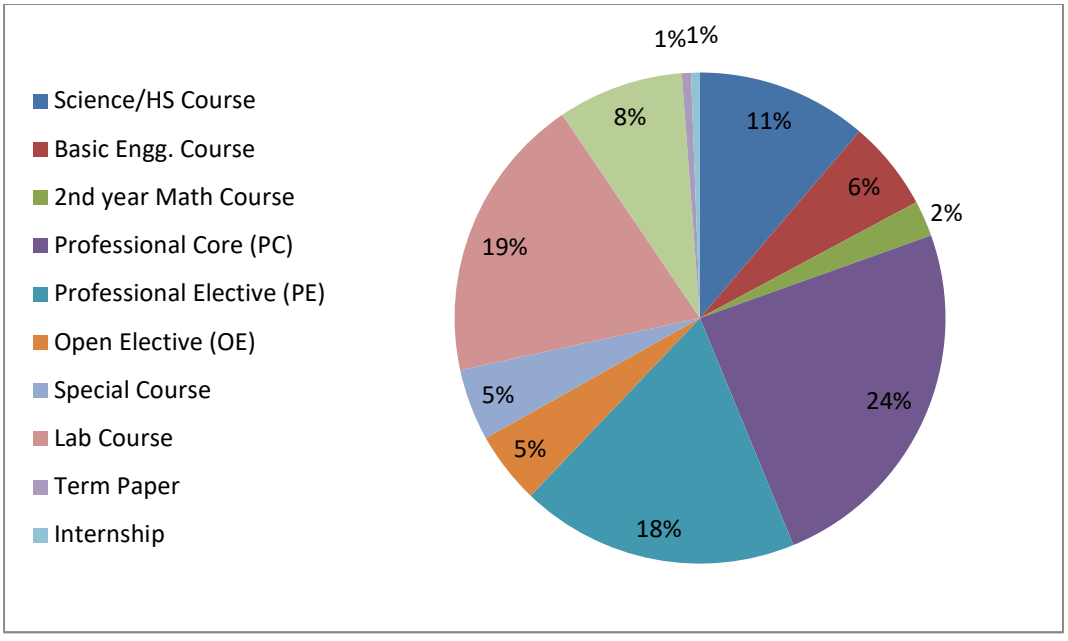
CS 413	Pattern Recognition	PE	3	0	0	3	None
CS 415	Complex Networks	PE	3	0	0	3	None
CS 417	Blockchain Technologies	PE	3	0	0	3	None
CS 419	High Performance Architecture	PE	3	0	0	3	None
Professional Elective –8							
CS 421	Image Processing	PE	3	0	0	3	None
CS 423	Artificial Intelligence	PE	3	0	0	3	None
CS 425	Advanced Web Technology	PE	3	0	0	3	None
CS 427	Software Defined Network	PE	3	0	0	3	None
CS 429	Robotics and Automation	PE	3	0	0	3	None
Open Elective –4							
CS 471	Data Analytics using Python	OE	2	0	0	2	None
Special Course – 3							
CE 491	Disaster Management	S	2	0	0	2	None
Lab Courses– 12							
CS 461	Computational Intelligence Lab	L	0	1	2	2	None
CS 481	Internship	I	0	0	0	1	None
Total Contact Hours – Component wise			**10**	**1**	**12**	---	
Total Contact Hours			**23**			**18**	---
SEMESTER –8							
Course Code	**Course Title**	**Course Type**	**Contact Hours**			**Credit**	**Pre-requisites**
			L	**T**	**P**	**C**	
CS 402	Project – II	P	0	0	18	9	None
Professional Elective –9							
CS 412	Mobile Computing	PE	3	0	0	3	None
CS 414	Cloud Computing	PE	3	0	0	3	None
CS 416	Wireless Sensor Network	PE	3	0	0	3	None
CS 418	Natural Language Processing	PE	3	0	0	3	None
CS 420	Cyber Forensics and Analysis	PE	3	0	0	3	None
Professional Elective –10							
CS 422	Data Mining	PE	3	0	0	3	None
CS 424	Distributed Computing	PE	3	0	0	3	None
CS 426	Bioinformatics	PE	3	0	0	3	None

CS 428	Internet of Things	PE	3	0	0	3	None
CS 430	Human Computer Interaction	PE	3	0	0	3	None
Special Course –4							
HS 492	Entrepreneurship	S	2	0	0	2	
Total Contact Hours – Component wise			**8**	**0**	**18**	---	
Total Contact Hours			**26**			**17**	---

Summary of Curriculum

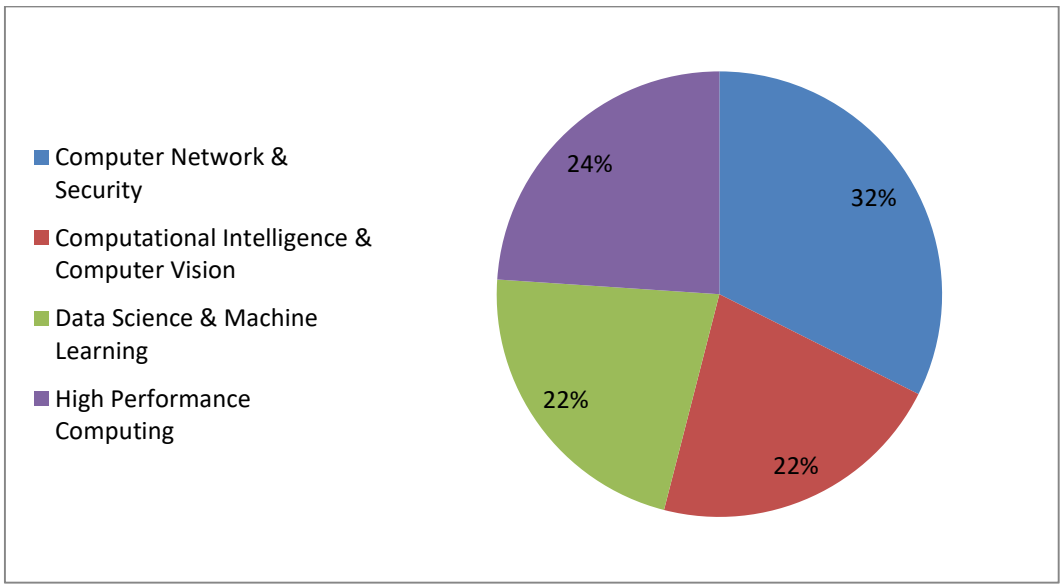
Credit Distribution based on Course Type

Course Type	Sem - 1	Sem - 2	Sem - 3	Sem - 4	Sem - 5	Sem - 6	Sem - 7	Sem - 8	Total
Science/HS Course (Sc/HS)	**9/10**	**10/9**	-	-	-	-	-	-	**19**
Basic Engg. Course (BE)	**8**	**5**	-	-	-	-	-	-	**13**
2nd year Math Course (M)	-	-	**4**	-	-	-	-	-	**4**
Professional Core (PC)	-	-	**11**	**11**	**11**	**8**	-	-	**41**
Professional Elective (PE)	-	-	-	**6**	**7**	**6**	**6**	**6**	**31**
Open Elective (OE)	-	-	-	**2**	**2**	**2**	**2**	-	**8**
Special Course (S)	-	-	**2**	-	-	**2**	**2**	**2**	**8**
Lab Course (L)	**3**	**5**	**5**	**5**	**5**	**4**	**2**	-	**32**
Project (P)	-	-	-	-	-	-	**5**	**9**	**14**
Term Paper (T)	-	-	-	-	-	**1**	-	-	**1**
Internship (I)	-	-	-	-	-	-	**1**	-	**1**
Total	**20/21**	**20/19**	**22**	**24**	**25**	**23**	**18**	**17**	**172**



Credit Distribution based on Research Group

Research Group	Sem – 1	Sem - 2	Sem - 3	Sem - 4	Sem - 5	Sem - 6	Sem - 7	Sem - 8	Total
Computer Network & Security	-	-	-	11	25	15	6	12	69
Computational Intelligence & Computer Vision	-	-	4	3	4	20	12	3	46
Data Science & Machine Learning	-	4	1	17	3	3	10	9	47
High Performance Computing	-	-	11	11	14	3	6	6	51
Total	--	4	16	42	46	41	34	30	213



National Institute of Technology Meghalaya

An Institute of National Importance

CURRICULUM

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-20**
Department	**Computer Science and Engineering**	Semester	**V**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS301	**Operating Systems**	**3**	**1**	**0**	**4**	**50**	**50**	**100**	**200**

Course Objectives	Course Outcomes	
To introduce the components of operating system	CO1	**Able to learn the fundamentals of Operating Systems**
To analyse the process scheduling and execution	CO2	**Able to acquire knowledge about different process scheduling techniques.**
To describe the structure of main memory, virtual memory	CO3	**Able to solve process synchronization and deadlock handling strategies**
To describe the function of file systems	CO4	**Able to acquire knowledge about different memory management techniques and page replacement algorithms.**
To explore the structure of an operating system's I/O subsystem and hardware.	CO5	**Able to describe file concepts and analyse various disk scheduling and storage strategies**

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**0**
2	CO2	**2**	**1**	**1**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**1**	**2**	**1**	**1**
3	CO3	**2**	**2**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**1**	**1**
4	CO4	**2**	**2**	**2**	**2**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**1**	**1**	**1**	**1**
5	CO5	**1**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**0**

SYLLABUS

No.	Content	Hours	COs
I	**Introduction** **Operating Systems Functionalities - Formal Definition - Evolution – Types of operating system, Services, Operating system Design and Implementation, Operating System Structure.**	**06**	**CO1**
II	**Process Management** **Process concept - Process control block, Process Hierarchy, Threads – Single Thread and Multi Thread Model, IPC models: shared memory and message passing. CPU Scheduling algorithms, Multiprocessor Scheduling, Process Synchronization - Peterson's Solution, Process Synchronization - Semaphores, Critical Regions, Monitors - Deadlock prevention- Deadlock avoidance and Deadlock Detection and Recovery - Bankers Algorithm.**	**16**	**CO2, CO3**
III	**Memory Management** **Overview of Swapping - Multiple Partitions – Paging, Page table, Segmentation, Demand paging- Fragmentation & Compaction- Page replacement algorithms, Memory allocation algorithms: first fit, Best fit, worst fit.**	**14**	**CO1, CO4**
IV	**File System** **Access Methods, Contiguous-Sequential and Indexed Allocation, File system interface - File System implementation, Secondary Storage Structure.**	**08**	**CO1, CO5**
V	**I/O System** **RAID-disk scheduling- Device drivers - block and character devices-streams, Character and Block device switch tables**	**04**	**CO1, CO5**
	Total Hours	**48**	

Essential Readings

1. Abraham Silberschatz, Peter Baer Galvin, Greg Gagne, “Operating System Concepts”, 9th Edition, John Wiley & Sons Inc. 2012.
2. Andrew S Tanenbaum, “Modern Operating Systems”, 4th Edition, Prentice Hall. 2014
3. William Stallings, “Operating System: Internals and Design Principles”, 9th Edition, Pearson, 2018.

Supplementary Readings

1. Harvey M. Deitel, Paul J. Deitel, David R. Choffnes, “Operating System”, 3rd Edition, Pearson, 2013.
2. D M Dhamdhere, “System Programming and Operating Systems”, 2nd Edition, Tata McGraw Hill, 2009.
3. Gary Nutt, “ Operating Systems: A Modern Perspective”, 2nd Edition, Addison Wesley, 2001.
4. Achyut S Godbole, “Operating Systems”, 3rd Edition, Tata McGraw Hill, 2010.

	National Institute of Technology Meghalaya An Institute of National Importance	CURRICULUM
Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation: **2019-2020**
Department	**Computer Science and Engineering**	Semester: **V**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS 303	**Database Management Systems**	**3**	**1**	**0**	**4**	**50**	**50**	**100**	**200**

Course Objectives	Course Outcomes	
To understand the fundamentals concepts of database, operation of relational data model and its requirement in an organization.		CO1 **Able to describe the fundamental components of database systems, Relational Database Management System and its need towards an organization.**
To understand the various relational data models, application of relational data models to design logical database including E-R diagrams and database normalization. And also write the simple and optimized advanced database queries using Structured Query Language (SQL).		CO2 **Able to demonstrate the data models, analyse the real world problems and requirements, to give the appropriate solution using the principles of Entity Relationship Diagram.**
To develop and ability to design and implement a small database project using Structured Query Language (SQL).		CO3 **Able to attain the practical understanding of SQL, convert the Entity relationship model to relational tables, operations to store the data using queries.**
To understand the requirement of database tuning, concept of a database transaction, including concurrency control, backup & recovery, data object locking protocols and role of database administrator.		CO4 **Able to apply the principles of normalization to remove the redundancy and inconsistency to improve the performance using database tuning and query optimization.**
		CO5 **Able to understand the concurrent transactions, Problems such as failures, solutions to solve the concurrency problems & recovery from failure using protocols**

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	3	3	0	0	0	0	0	0	2	0	0	0	3	0	3
2	CO2	3	3	3	1	2	0	0	0	1	0	0	0	2	3	2
3	CO3	1	2	3	3	2	2	0	0	0	0	0	0	2	3	3
4	CO4	1	2	3	3	3	2	3	0	2	0	0	1	2	3	2
5	CO5	2	3	3	2	2	3	2	0	2	0	0	1	3	3	3

SYLLABUS

No.	Content	Hours	COs
I	**Introduction to Database: Purpose of database systems, data abstraction and modeling, instances and schemes, database manager, database users and their interactions, data definition and manipulation language, data dictionary, overall system structure.**	**03**	**CO1** **CO2**
II	**Entity-relationship model:** **Entities and entity sets, relationships and relationship sets, mapping constraints, E-R diagram, primary keys, strong and weak entities, reducing E-R diagrams to tables, trees or graphs,** **generalization and specialization, aggregation.**	**06**	**CO1** **CO2**
III	**Brief Introduction to hierarchical and network model:** **Data description and tree structure diagram for hierarchical model, retrieval and update facilities, limitations;** **Database task group (DBTG) model, record and set constructs retrieval and update facilities, limitations.**	**05**	**CO2** **CO3**
IV	**Relational model and Query optimization:** **Structure of a relational database, operation on relations, relational algebra, tuple and domain relational calculus, salient feature of a query language, Structured query language: Description an actual RDBMS and SQL.** **Importance of query processing, equivalence of queries, cost Estimation for processing a query, general strategies, bi-relational and multi-relational join algorithms, algebraic manipulation.**	**09**	**CO2** **CO3** **CO4**
V	**Normalization:** **Pitfalls in RDBMS, importance of normalization, functional, multi-valued and join dependencies, 1NF to 5NF, limitations of RDBMS.**	**08**	**CO4** **CO5**
VI	**Database tuning:** **Index selection and clustering, tuning of conceptual schema, denormalization, tuning queries and views.**	**05**	**CO2** **CO4**
VII	**Crash recovery:** **Failure classification, transactions, log maintenance, check point implementation, shadow paging, example of an actual implementation**	**06**	**CO5**
VIII	**Concurrency Control in RDBMS:** **Testing for serializability, lock based and time-stamp based protocols; Deadlock detection and Recovery**	**08**	**CO4** **CO5**
	Total	**50**	

Essential Readings

1. Silberschatz, Korth and Sudarshan, Database system concepts, McGraw Hill, 7th Edition, 2019.
2. C.J. Date, An Introduction to Database Systems (8th Edition), Pearson, 8th Edition, 2004.
3. Steven Feuerstein, Bill Pribyl, “Oracle PL/SQL Programming,”, O'Reilly Media, 6th Edition, 2014.

Supplementary Readings

1. Elmasri and Navathe, Fundamentals of database systems; Pearson, 7th Edition, 2016.
2. Raghu Ramakrishnan and Gehrke, Database Management System, McGraw-Hill, 3rd Edition, 2014.
3. C. J. Date, SQL and Relational Theory: How to Write Accurate SQL Code, O'Reilly Media, 3rd Edition, 2015.

	National Institute of Technology Meghalaya An Institute of National Importance	**CURRICULUM**

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-20**
Department	**Computer Science and Engineering**	Semester	**V**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS 305	**Computer Networks**	**3**	**0**	**0**	**3**	**50**	**50**	**100**	**200**

Course Objectives	Course Outcomes		
To develop the student's ability to understand the basic concept of networking, packet switching and circuit switching etc.		CO1	**Able to understand the brief of internet and also the concept of circuit switching and packet switching.**
To develop the student's ability to understand the application layer of the network model along with the ability to perform socket programming.		CO2	**Able to understand the purpose of application layer and various application layer protocols such as DNS, FTP, SMTP.**
To provide the students with some knowledge and analysis skills associated with transport layer protocols TCP and UDP.		CO3	**Able to understand various transport layer protocol like UDP, TCP, and various mechanisms to control TCP congestion.**
To develop the student's ability to understand the network layer of network model like IPv4 addressing NAT etc.		CO4	**Able understand the IPV4 addressing and forwarding mechanism and solve relevant problems.**
		CO5	**Able to understand the routing algorithms and protocols and solve relevant problems.**
		CO6	**Able to understand the concepts of network security and management, and the future trends of networking.**

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	2	0	0	0	0	1	0	2	0	0	0	2	1	1	1
2	CO2	2	2	2	1	2	0	0	2	0	2	0	1	2	2	1
3	CO3	3	2	2	3	0	0	2	1	0	1	1	1	2	1	1
4	CO4	1	1	0	1	0	0	0	2	1	1	0	2	3	1	3
5	CO5	0	1	1	1	2	3	0	2	1	1	1	1	1	2	1
6	CO6	2	0	3	0	1	1	1	1	1	2	1	1	3	3	3

SYLLABUS

No.	Content	Hours	COs
I	**Basics of Internet:** **Internet Service Providers (ISPs); protocols and standards; Network edge - access networks: dial-up, DSL, cable, FTTH, Ethernet, WiFi, WiMax; Network core - circuit switching: multiplexing; packet switching: traffic, congestion; delays; traffic intensity; throughput; protocol layering;**	**04**	**CO1**
II	**Application Layer:** **Architecture – client-server, peer-to-peer, hybrid; DNS: brief, hierarchical database; Internet transport services; The Web and HTTP - What actually happens, HTTP request and response, web cache; Process communication; Socket programming; File transfer: FTP; Electronic mail: SMTP, POP3, IMAP, Web-based e-mail;**	**05**	**CO2**
III	**Transport Layer:** **Real Life Analogy; Multiplexing and De-multiplexing; TCP and UDP sockets; Web Servers and TCP; Why UDP?; TCP UDP Examples; UDP Segment; TCP Segment; Flow Control - Stop and Wait, Go-Back-N, Selective Repeat; Transmission Control Protocol; TCP Connection Establishment - Three-Way Handshaking, Data Transfer, Connection Termination; SYN Flooding Attack; TCP Congestion Control - congestion window, congestion detection, Slow Start: Exponential Increase, Congestion Avoidance: Additive Increase, Additive Increase Multiplicative Decrease; TCP Variants - Tahoe and Reno;**	**06**	**CO3**
IV	**Network Layer – Part 1:** **Functions; Packet Switching - Virtual Circuit, Datagram; What's inside a router? - Input Processing, Switching, Output Processing; IPV4 Address - Classful Addressing, Classless Addressing - address mask, block allocation, subnetting; Special Addresses; IP Datagram, Fragmentation; Dynamic Host Configuration Protocol - properties, protocol steps; Network Address Translation;**	**08**	**CO4**
V	**Network Layer – Part 2 (Routing Algorithms and Protocols):** **Distance Vector Routing; Link State Routing; Path Vector Routing; Routing Information Protocol; Open Shortest Path First; Border Gateway Protocol; Multicast routing protocol; Wireless routing protocol;**	**09**	**CO5**
VI	**Security and Network Management:** **Cryptography and Network Security; Internet Security: IPSec, SSL/TLS and PGP; SNMP;**	**02**	**CO6**
VII	**Future Trends:** **Internet-of-Things (IoT); Software Defined Networking (SDN)**	**02**	**CO6**
	Total Hours	**36**	

Essential Readings

1. J. F. Kurose, K. W. Ross, "Computer Networking: A Top-Down Approach", Pearson Publication, 6th Edition, 2013.
2. B. Forouzan, "Data Communication and Networks", McGraw-Hill Publication, 5th Edition, 2012.
3. A. S. Tanenbaum, D. J. Wetherall, "Computer Networks", Pearson Publication, 5th Edition, 2011.

Supplementary Readings

1. W. Stalling, "Data and Computer Communications", Pearson Publication, 8th Edition, 2007.
2. L. L. Peterson, B. S. Davie, "Computer Networks: A Systems Approach", Morgan Kaufmann Publishers, 5th Edition, 2012.
3. A. L. Garcia and I. Widjaja, "Communication Networks Fundamental Concepts and Key Architectures", Tata McGraw-Hill Publication, 2nd Edition, 2004.

	National Institute of Technology Meghalaya An Institute of National Importance	**CURRICULUM**

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-20**
Department	**Computer Science and Engineering**	Semester	**V**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS 311	**Microprocessors and Interfacing**	**3**	**1**	**0**	**4**	**50**	**50**	**100**	**200**

Course Objectives		Course Outcomes		
	Introduce students about the architecture, internal organization of an 8-bit (8085) processor in detail.		CO1	Recall and apply a basic concept of digital fundamentals to microprocessor based personal computer system.
	This subject also deals about interfacing an external device with the processors/ controllers.		CO2	Identify a detailed software & hardware structure of the 8085 Microprocessor.
	Introduce students to programming in assembly language.		CO3	Illustrate how the different peripherals (8255, 8253 etc.) are interfaced with Microprocessor.
			CO4	Distinguish and analyse the properties of different Microprocessors & Microcontrollers.
			CO5	Analyse the data transfer information through serial & parallel ports.
			CO6	Design and evaluate assembly language programs and the machine code that will provide solutions real-world problems.

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**3**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**2**	**2**
2	CO2	**3**	**1**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**3**
3	CO3	**3**	**3**	**3**	**2**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**3**
4	CO4	**3**	**1**	**3**	**2**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**3**
5	CO5	**3**	**2**	**3**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**3**
6	CO6	**3**	**3**	**3**	**2**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**2**

SYLLABUS

No.	Content	Hours	COs
I	Introduction to Computer architecture, Architecture of a typical Microprocessor, Bus configuration, The CPU module, The MPU and The microcontroller. Timing diagram, Memory Interfacing, Interfacing input output- port, Interrupt & interrupt handling, Serial & parallel data transfer scheme, Programmed & interrupt driven data transfer, Direct memory access, Programmable peripheral devices, Programmable interval timer, Analog input-output using AD & DA converter	**17**	**CO1, CO2, CO3, CO4**
II	Introduction to assembly language & machine language programming, Instruction set of typical microprocessor (e.g. 8085), Subroutine & stack.	**10**	**CO1, CO6**
III	Basic Interfacing Concepts, 8255 Programmable Peripheral Interface, Interfacing Display, Keyboards, 8279 Programmable Keyboard/Display Interface, 8253/54 Programmable Timer, DMA Controller, Interrupt Controller, ADC And DAC Interfacing.	**15**	**CO5, CO5**
IV	8086 Internal Architecture, Memory Segmentation, Addressing Modes, Basic Bus Timing During Read And Write Operation.	**06**	**CO1, CO4**
	Total Hours	**48**	

Essential Readings:

1. Gaonkar R. S., “Microprocessor Architecture, Programming and Applications with 8085”, 5th ed., 2000, Penram International.
2. Douglas Hall And S S S P Rao, “Microprocessor and Interfacing”, 3rd ed., 2012, Tata McGraw-Hill.
3. Ajay wadhwa,"microprocessor 8085: architecture, programming, and interfacing", 1st ed., 2010, PHI Learning.

Supplementary Readings:

1. Ram B., “Fundamental of Microprocessor & Microcomputers”, 6th ed., 2003, Dhanpat Rai Publications.
2. Leventhal Lance, “Introduction to Microprocessor - Software, Hardware and Programming”, 5th ed., 1992, PHI.
3. Barry B. Brey,"The Intel Microprocessor: Architecture, Programming, and Interfacing", 8th ed., 2008, Pearson.

	National Institute of Technology Meghalaya An Institute of National Importance	CURRICULUM
Programme	**Bachelor of Technology in Computer Science & Engineering**	Year of Regulation: **2019**
Department	**Computer Science & Engineering**	Semester: **VI**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS 313	**Embedded Systems**	**3**	**1**	**0**	**4**	**50**	**50**	**100**	**200**

Course Objectives	**COB1: To develop the student's ability to understand the concept of embedded system's characteristics, requirements and architecture.**	Course Outcomes	CO1	Students should be able to Understand the computer architectural design principles and performance enhancement strategies that adopted in performance evolution of different components of computer, microprocessor / microcontroller and Digital signal processor architecture and distributed memory architecture and distributed systems.
	COB2: To develop the student's ability to understand the fundamentals of microprocessor and micro-controller families and their architecture with special emphasis on Digital Signal Processors.			
	COB3: To provide the students with some knowledge and analysis skills associated with the principles of memory organisation and bus structure of embedded system.		CO2	Students should be able to Solve the performance related problems of real time operating system.
	COB4: To develop the student's ability to understand the concepts of embedded system software with special emphasis on real time operating system and particularly real time job scheduling.			
	COB5: To provide the students with some basic knowledge of power aware architecture & hardware software co design.		CO3	Analyze the performance of embedded processing, memory, bus efficiencies, real time operating system performance h/w s/w codesign.

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO 3
1	CO1	3	1	1	-	-	-	-	1	1	-	-	2	-	1	-
2	CO2	3	3	2	2	2	-	-	1	1	-	-	2	1	1	-
3	CO3	3	3	3	2	2	-	-	2	2	-	-	2	2	2	-

SYLLABUS

No.	Content	Hours	COs
Module 0: Basic 8085 programming & Interfacing	Introduction to 8-Bit 8085 Microprocessor Architecture, Operation, Memory Interfacing, Interfacing I/O Devices, Instruction Classification, Overview of 8085 Instruction Set Timings And Operations Of Instruction Cycle, Assembly Language Programming Using Different Programming Techniques Like Looping, Counting and Indexing, Time Delay Programs, Stack And Subroutines, Basic Interfacing Concepts, 8255 Programmable Peripheral Interface, Interfacing Display, Keyboards, 8279 Programmable Keyboard/Display Interface.	**12**	**CO1**
Module1: Embedded systems	Introduction, Characteristics, Application dependent requirements, Architecture, Challenges, Development Process.	**02**	**CO1 & 2**
	Embedded System Hardware: Microprocessor, micro-controller, Von-Neumann and Harvard architecture, RISC, CISC.	**03**	**CO1, 2 & 3**
Module2: PIC Microcontroller Family	PIC architecture, Clocking scheme, Instruction execution, Instruction pipeline. PIC Instruction set, Instruction format, Addressing modes, PIC peripherals on chip, Interrupts, PIC timers.	**04**	**CO1 & 2**
Module3: Case Study	8051 micro-controller, ARM processor	**02**	**CO1&2**
Module4: Digital Signal Processors	Features, Application, Memory, Addressing. System on Chip (SoC): Evolution, Design, Platforms, Multi Processor SOC.	**03**	**CO1 & 2**
Module5: Memory	Basic organization, Embedded SRAM, Embedded DRAMS, Flash Memory, Virtual Memory, Memory Management Unit (MMU), Paging.	**04**	**CO1 & 2**
Module6: Bus Structures, interrupt handling	Bus Structures, interrupt handling	**04**	**CO1,2 &3**
Module7: Power Aware Architectures	Power Density, Power Dissipation, Power vs Speed, Power consumption of CMOS circuits, Gating, Dynamic Power Management.	**04**	**CO1,2 &3**
Module8: Software for Embedded systems	Features, Memory Allocation, Heap Management.	**02**	**CO1&2**
Module9: Fundamentals of Embedded Operating System	Real time operating system	**07**	**CO2&3**
Module10: Hardware-Software Co-design	Introduction, methodology and concepts	**03**	**CO1,2&3**
Total Hours		**50**	

Essential Readings

1. Wayne Wolf , “Computers as Components: Principles of Embedded Computing System Design”, Second Edition, Morgan Kaufmann, 2006.
2. M. A. Mazidi , J. G. Mazidi and R. D. Mckinlay others, “The 8051 Microcontroller and Embedded Systems”, Second Edition, Prentice Hall of India, 2008.
3.R. H. Barnett, L. O'Cull, S. Alison Cox, “Embedded C Programming and Microchip PIC”, First Edition, Thomson Learning Inc., 2008.
Supplementary Readings
1. Andrew M Sloss, Dominic Symes, Chris Wright, “ARM System Developers Guide: Designing optimizing System Software” (Online resource)
2. http://eee.guc.edu.eg/Courses/Electronics/ELCT912%20Advanced%20Embedded%20Systems/Lectures/ARM%20System%20Developer%27s%20Guide.pdf
3. T. Wilmshurst , “An introduction to design of small scale embedded systems”, First Edition, Palgrame Macmillan Publishers, 2001.
4. J. B. Peatman , “Design with PIC Microcontroller”, Second Edition, Pearson Education, 2002.

	National Institute of Technology Meghalaya An Institute of National Importance	CURRICULUM

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-20**
Department	**Computer Science and Engineering**	Semester	**V**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS315	**E-Commerce and Cyber Laws**	**3**	**1**	**0**	**4**	**50**	**50**	**100**	**200**

Course Objectives		Course Outcomes		
	To develop the student's ability to understand the concept of e-commerce.		CO1	**Able to acquire knowledge about e-commerce and the network of e-commerce**
	To provide the students about electronic retailing		CO2	**Able to acquire knowledge about the background of economics of e-commerce, and understand Electronic Retailing**
	To develop the student's ability to analyse the security involved in the networking where e-commerce is done.		CO3	**Able to understand and analyse the network security which is the base of e-commerce.**
	To familiarize the student the need of security in electronic payment done in e-commerce.		CO4	**Able to understand and analyse the electronic payment system and its privacy and social impacts.**
	To familiarize the student the legal issues related to digital world.		CO5	**Able to understand and analyse the legal issues, public policies, international issues in the digital world.**

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**3**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**3**
2	CO2	**3**	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**1**	**0**	**3**	**2**	**2**
3	CO3	**3**	**3**	**3**	**1**	**2**	**1**	**2**	**0**	**2**	**0**	**0**	**0**	**3**	**3**	**2**
4	CO4	**2**	**3**	**3**	**1**	**2**	**2**	**2**	**0**	**2**	**0**	**1**	**1**	**2**	**2**	**3**
5	CO5	**2**	**3**	**3**	**1**	**2**	**2**	**2**	**0**	**2**	**0**	**3**	**1**	**1**	**2**	**3**

SYLLABUS

No.	Content	Hours	COs
I	Introduction to Electronic commerce: Defining e-commerce, History of money and electronic money. The Network Infrastructure for Electronic Commerce: The Internet and WWW Technology, digital convergence and commerce.	**06**	**CO1**
II	Economics of Electronic Commerce: Transactions and Accounting Costs, Pricing of Goods and Services on the Internet. Electronic Retailing: Web Based Business Models, Purchasing Agents, Online Shopping Marketing and Advertising on the Net: Emerging marketing and advertising models.	**10**	**CO2**
III	Network Security: Firewalls, Encryption and Transaction Security (Secret Key and Public Key Cryptography), Digital Signatures, Certificates, Certificate Authorities.	**10**	**CO3**
IV	Electronic Payment Systems: Tokenized vs. Notational systems, Credit Card based systems, Electronic Checks, Electronic Cash and Micro transactions, Smart Cards, Protocols and Standards. Privacy, Anonymity and Social Impacts of Electronic Cash Topics: Privacy, Anonymity, and traceable E-money.	**12**	**CO4**
V	Legal Issues: Electronic Contracting and Digital Signatures, Intellectual Property, Copyright, Trademark, and Patents, Cybercrime and Money Laundering. Public Policy Issues: What is the Government's role? Electronic Commerce and Financial Services Topics: Banking, Securities and Brokerage International Issues/Commerce, Copyright and Online Publishing Topics: Commodification of Information, Property Rights vs. Freedom of Information, Electronic publishing and digital copyrights	**10**	**CO5**
	Total Hours	**48**	

Essential Readings

1. Lynch/Lundquist, Digital Money: The New Era of Internet Commerce, Wiley Publications, 1st Edition, 1996.
2. Joseph Migga Kizza, Computer Network Security and Cyber Ethics, McFarland & Company, 3rd Edition, 2011.
3. Jaynice Reynolds, The Complete E-commerce Book, CRC Press, 2nd Edition 2004.

Supplementary Readings

1. Henry Chan et. al, E-Commerce, Fundamentals and Applications, Wiley Publications, 1st Edition, 2001.
2. Jyoti Rattan, Vijay Rattan, Cyber Laws & Information Technology, Bharat Law House, 1st Edition, 2017.
3. Donna L. Hoffman, Thomas P.Novak, A New Marketing Paradigm for Electronic Commerce, The Information Society, Vol. 13, No. 1, 1997.

	National Institute of Technology Meghalaya An Institute of National Importance	CURRICULUM

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-20**
Department	**Computer Science and Engineering**	Semester	**V**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS 317	**Machine Vision**	**3**	**1**	**0**	**4**	**50**	**50**	**100**	**200**

Course Objectives	To Use mathematical modeling tools to represent digital images	Course Outcomes	CO1	Represent and interpret image in its numeric and graphical form
	To apply morphological operations for shape recognition and template matching		CO2	Understand geometric relationship of pixels
	To be able to use advanced algorithms such as support vector machines and artificial neural networks for object recognition and classification.		CO3	Able to understand the principle and use of Machine Vision system for industrial quality control.
	To apply stereo vision techniques and optical flow methods to study motion.		CO4	Able to acquire knowledge regarding shape identification and pattern recognition in industrial robotics application
	To give a clear idea of industrial quality control and inspection of end product.		CO5	Able to acquire knowledge about Automated Target Recognition

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**1**	**1**	**2**	**1**	**2**	**1**	**0**	**0**	**2**	**0**	**0**	**0**	**3**	**0**	**3**
2	CO2	**1**	**1**	**2**	**1**	**3**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**2**	**0**	**2**
3	CO3	**2**	**1**	**3**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**3**	**2**
4	CO4	**2**	**2**	**3**	**0**	**2**	**2**	**3**	**0**	**2**	**0**	**0**	**1**	**2**	**3**	**2**
5	CO5	**2**	**2**	**3**	**0**	**2**	**2**	**3**	**0**	**2**	**0**	**0**	**1**	**3**	**3**	**3**
6	CO6	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

SYLLABUS

No.	Content	Hours	COs
I	**Review of Mathematical Principles:** A brief review of probability, A review of Linear Algebra, Introduction to Function Minimization, Markov Models	**08**	**CO1**
II	Machine vision: Introduction to Machine Vision,, definition, Active vision system, Machine vision components, hardware's and algorithms, image function and characteristics, segmentation, data reduction, feature extraction, edge detection, image recognition and decisions, m/c learning, application of machine vision such as in inspection of parts, identification, industrial robot control, mobile robot application, Competing technologies, CCD line scan and area scan sensor, Triangulation geometry, passive and active stereo imaging, laser scanner, data processing.	**12**	**CO2**
III	Industrial Machine Vision: Industrial Machine Vision in production and services, Structure of Industrial Machine Vision, Generic Standards, Interfacing Machine Vision System, vision system calibration. Shape Identification, Statistical Pattern Recognition and Syntactic Pattern Recognition	**10**	**CO1** **CO3**
IV	Automated Target Recognition (ATR): The hierarchy of levels of ATR, ATR System Components, and Performance Evaluation of ATR Systems Machine Vision issues to ATR, ATR Algorithms, Hugh Transform in ATR, Morphological Techniques in ATR.	**10**	**CO2** **CO3**
V	**Applications of Machine Vision:** Multispectral Image Analysis, Optical Character Recognition, Industrial Inspection and Quality Control, Security and Intruder identification, Robot Vision	**08**	**CO4** **CO5**
Total Hours		**48**	

Essential Readings

1. Machine Vision By Wesley E. Snyder, Cambridge University Press, 2012.
2. Machine Vision Algorithms and Applications, 2nd Edition , By Carsten Steger, Markus Ulrich, Christian Wiedemann, Wiley Publication, 2018.
3. Computer and Machine Vision: Theory, Algorithms, Practicalities, By E. R. Davies, 4th Edition, Academic Press, 2012.

Supplementary Readings

1. Computer Vision: Principles, Algorithms, Applications, Learning, 5th Edition By E. R. Davies, Academic Press, 2017.
2. Mechatronics and Machine Vision, By John Billingsley, Research Studies Press, 2000.
3. Mechatronics and Machine Vision in Practice, By John Billingsley, Robin Bradbeer, Springer Science & Business Media, 2007.

	National Institute of Technology Meghalaya An Institute of National Importance	**CURRICULUM**

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-20**
Department	**Computer Science and Engineering**	Semester	**V**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS 319	**Automata and Formal Languages**	**3**	**0**	**0**	**3**	**50**	**50**	**100**	**200**

Course Objectives	Course Outcomes		
To introduce students to theory of computation: automata, computability, and complexity with application of mathematical techniques and logical reasoning to important problems,		CO1	Student will be able to demonstrate the fundamental understanding of the core concepts in automata theory and formal languages.
To develop a strong background in reasoning about finite state automata and formal languages.		CO2	Student will be able to design grammars and automata for different language classes.
To introduce students to different ways of parsing a formal language.		CO3	Student will be able to identify formal language classes and prove language membership properties.
		CO4	Student will be able to prove and disprove theorems establishing key properties of formal languages and automata.
		CO5	Student will be able to demonstrate a fundamental understanding of computation and computational models including decidability and intractability.

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**3**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**3**	**1**
2	CO2	**2**	**2**	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**1**
3	CO3	**2**	**2**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**1**
4	CO4	**1**	**2**	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**1**
5	CO5	**3**	**3**	**1**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**3**	**3**	**1**

SYLLABUS

No.	Content	Hours	COs
I	Basic Mathematical Objects: Sets Logic, Functions, Relations, Strings, Alphabets, Languages, Mathematical Induction: Inductive proofs, Principles; Recursive definitions.	**02**	**CO1**
II	Regular Languages and Finite Automata (FA), Deterministic and Nondeterministic Finite Automata, Equivalence and minimization of Automata, Finite Automata with output- Mealy and Moore Machines, Properties of Regular Sets: The Pumping Lemma for Regular sets, Closure properties and Decision properties of regular languages, Regular Expressions (RE), Relation Between RE and FA.	**14**	**CO1, CO2**
III	Grammar , Types of Grammar and Languages- Chomsky Hierarchy, Context Free Grammar (CFG), Derivation trees & Ambiguity, Inherent ambiguity, Parse tree, Application of CFG, Simplification of CFG, Normal form of CFG, Relations between classes of languages and Automata, Closure properties and Decision properties of CFG, Properties of Context Free Languages: The Pumping Lemma,	**13**	**CO1, CO2, CO3**
IV	Push Down Automata(PDA), Languages of PDA, Equivalence of PDA and CFG, Deterministic PDA	**04**	**CO1, CO2,CO4**
V	Turing Machine(TM) - Standard Model, Variations of TM (Multi-Track TM, Multi-Tape TM, Multi-Dimensional TM, Universal TM), Deterministic and Non deterministic TM, Turing Thesis, Halting Problem, Language of a Turing Machine- Recursively Enumerable Language, Unrestricted Grammar, Linear Bounded Automata(LBA), Computability and Decidability. Time and Space Complexity, Growth Rate, Complexity classes, Tractable and Non tractable Problems: P and NP, Cooks's theorem.	**6**	**CO1, CO4,CO5**
Total Hours		**39**	

Essential Readings:

1. Peter Linz, "An Introduction To Formal Languages And Automata", 3rd ed., 2001, Narosa Publication.
2. K.L.P.Mishra, N. Chandrasekaran," Theory Of Computer Science: Automata, Languages and Computation", 3rd ed., 2016, PHI.
3. S. Kandar, "Introduction to Automata Theory, Formal Languages and Computation", 1st ed., 2013, Pearson.

Supplementary Readings:

1. John E. Hopcroft, Rajeev Motwani, Jeffrey Ullman, "Introduction to Automata theory, languages computation ", 2nd ed., 2005, Pearson India, Indian Reprint.
2. Michael Sipser, "Introduction to the Theory of. Computation", 3rd ed., 2013, Cengage Learning.
3. H. R. Lewis, C. H. Papadimitriou, "Elements of the Theory of Computation", 2nd ed., 1998, Prentice-Hall.

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CURRICULUM

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-2020**
Department	**Computer Science and Engineering**	Semester	**V**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS 321	**Formal Verification**	**3**	**0**	**0**	**3**	**50**	**50**	**100**	**200**

Course Objectives	Course Outcomes		
To understand the fundamental concepts of formal verification		CO1	**Able to understand the fundamental concept of formal verification**
To demonstrate the modeling of sequential systems, linear time properties, linear temporal logic, computation tree logic, model checking CTL and model checking LTL		CO2	**Able to demonstrate the modeling of sequential systems, linear time properties, linear temporal logic**
To explain binary decision diagrams, symbolic model checking, model checking with SAT, bounded model checking, craig interpolation		CO3	**Able to explain computation tree logic, model checking CTL and model checking LTL**
To understand decision procedures in model checking, practical industrial-scale verification		CO4	**Able to demonstrate binary decision diagrams, symbolic model checking**
		CO5	**Able to demonstrate model checking with SAT, bounded model checking, craig interpolation**
		CO6	**Able to explain decision procedures in model checking, practical industrial-scale verification**

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	3	3	0	0	0	0	0	0	2	0	0	0	3	0	3
2	CO2	3	3	3	1	2	0	0	0	1	0	0	0	2	3	2
3	CO3	1	2	3	3	2	2	0	0	0	0	0	0	2	3	3
4	CO4	1	2	3	3	3	2	3	0	2	0	0	1	2	3	2
5	CO5	2	3	3	2	2	3	2	0	2	0	0	1	3	3	3
6	CO6	1	2	3	3	3	2	3	0	2	0	0	1	2	3	2

SYLLABUS

No.	Content	Hours	COs
I	**Introduction to Formal Verification**	**02**	**CO1**
II	**Modelling sequential systems as labelled transition systems (Kripke structures), Linear time properties, Linear temporal logic (LTL).**	**06**	**CO2**
III	**Computation tree logic (CTL) and CTL* , Model checking CTL , Model checking LTL**	**06**	**CO3**
IV	**Counterexamples and witnesses, Binary decision diagrams (BDD), Symbolic model checking**	**06**	**CO4**
V	**Model checking with SAT, bounded model checking, Completeness thresholds and k-induction, Craig interpolation**	**08**	**CO5**
VI	**Equivalences and abstractions, Decision procedures in model checking, Practical, industrial-scale verification, present challenges**	**08**	**CO6**
	Total	**36**	

Essential Readings

1. *Principles of Model Checking*, by C. Baier and J.-P. Katoen, The MIT Press, 2008 edition.
2. *Model Checking*, by Edmund M. Clarke, Jr., Orna Grumberg, and Doron A. Peled, The MIT Press, 2nd edition, 2000.
3. *Logic in Computer Science: Modelling and reasoning about systems*, by Michael Huth and Mark Ryan, Cambridge University Press, 2nd edition, 2004.

Supplementary Readings

1. *Introduction to Formal Hardware Verification*, by Thomas Kropf, Springer, 1999 edition.
2. *Formal Hardware Verification: Methods and Systems in Comparison*, Ed. by Thomas Kropf, Springer, 1997 edition.
3. *Advanced Formal Verification*, by Rolf Drechsler, Springer, 2004 edition.

	National Institute of Technology Meghalaya An Institute of National Importance	CURRICULUM

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-20**
Department	**Computer Science and Engineering**	Semester	**V**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS 323	**COMPUTATIONAL GEOMETRY**	**3**	**0**	**0**	**3**	**50**	**50**	**100**	**200**

Course Objectives		Course Outcomes		
	To introduce techniques for designing efficient algorithms for geometric problems.		CO1	Develop efficient algorithms by exploiting geometric properties, and using appropriate data structures and geometric techniques.
	To discuss data structures used for geometric problems		CO2	Apply techniques and algorithms for solving problems in diversified fields like database searching, data mining, graphics and image processing, pattern recognition, computer vision, motion planning and robotics.
	To introduce combinatorial complexity of geometric problems.		CO3	Perform complexity analysis of algorithms
	To study rigorous algorithmic analysis of geometric problems.		CO4	Identify properties of geometric objects, express them as lemmas or theorems, and prove their correctness
			CO5	Implement geometric algorithms
			CO6	

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**3**	**3**	**0**	**1**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**3**	**0**	**3**
2	CO2	**3**	**3**	**0**	**1**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**2**	**0**	**2**
3	CO3	**2**	**3**	**3**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**3**	**2**
4	CO4	**2**	**2**	**3**	**0**	**2**	**2**	**3**	**0**	**2**	**0**	**0**	**1**	**2**	**3**	**2**
5	CO5	**2**	**2**	**3**	**0**	**2**	**2**	**3**	**0**	**2**	**0**	**0**	**1**	**3**	**3**	**3**
6	CO6	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

SYLLABUS

No.	Content	Hours	COs
I	Geometric Preliminaries, DCEL (Doubly Connected Edge List) data structure, Polygon, Planar Straight Line Graph (PSLG) Area of a triangle, area of a polygon, Determinant used to test position of a point with respect to a directed line. Convex polygons, properties and point location in convex polygon (inside-outside test) Plane sweep algorithm, Algorithm for Line segment intersection problem using plane sweep technique.	**06**	**CO1**
II	Point location in PSLG – Slab method, Chain method and complexity analysis. Range Searching – 1D Range search, Kd Trees.	**06**	**CO1, CO2**
III	Polygon Triangulation: Regularization of polygons, properties of triangulations –Proofs, triangulation of monotone polygon – algorithm and complexity analysis. Linear Programming – Half plane intersection, Incremental algorithm and Randomized algorithm	**08**	**CO1 CO2 CO3**
IV	Art Gallery Theorem, Guarding Art Gallery, Fisk's proof using three colouring. Arrangements of Lines – Duality, Combinatorics of arrangements, Zone Theorem, Algorithm for Constructing arrangements of lines.	**06**	**CO3 CO4**
V	Convex Hulls- Convex Hull Algorithms in the Plane -Graham's Scan Algorithm, Jarvi's March, Divide and Conquer Algorithm.	**06**	**CO4 CO5**
VI	Voronoi Diagrams- Properties and applications in the plane. Proofs of properties related to vertices and edges of voronoi diagrams, Algorithm for constructing voronoi diagram, Delaunay Triangulation.	**08**	**CO2 CO5**
	Total Hours	**40**	

Essential Readings:

1. Franco P. Preparata and Michael Ian Shamos, Computational Geometry an Introduction. Texts and Monographs in Computer Science, Publisher: Springer-Verlag Berlin Heidelberg, 1985, 1st Edition.
2. Joseph O'Rourke, Computational Geometry in C. Cambridge University Press, 2nd Edition, 2012.
3. Mark. de Berg, Marc. van Kreveld, Mark. Overmars and Otfried Cheong, Computational Geometry- Algorithms and Applications. Publisher: Springer-Verlag Berlin Heidelberg, 3rd Edition, 2008.

Supplementary Readings:

1. Herbert Edelsbrunner, Algorithms in Combinatorial Geometry, EATCS Monographs on Theoretical Computer Science, Publisher: Springer-Verlag Berlin Heidelberg, 1987, 1st Edition.
2. Joseph O' Rourke, Art Gallery Theorems, Publisher: Oxford University Press, 1987, 1st Edition.
3. De Berg, van Kreveld, Overmars, and Schwarzkopf Computational, Geometry Algorithms and Applications, Publisher: Springer-Verlag Berlin Heidelberg, 2000, 2nd Edition.

	National Institute of Technology Meghalaya An Institute of National Importance	**CURRICULUM**

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-20**
Department	**Computer Science and Engineering**	Semester	**V**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS 325	**Modern Digital Arithmetic**	**3**	**0**	**0**	**3**	**50**	**50**	**100**	**200**

Course Objectives		Course Outcomes		
	To teach different data representation used in a digital computer and device.		CO1	Identify, understand and apply different number systems and codes.
			CO2	Understand and use the advanced addition algorithms for multioperand addition/subtraction.
	To discuss different ways of hardware design for arithmetic operations.		CO3	Understand the concept of advanced multipliers and their uses in different situations.
			CO4	Understand the concept of advanced dividers and their uses in different situations.
	To introduce different techniques employed to speed up the computer and processing unit.		CO5	Understand the concept of advanced pipelining and other methods used to increase the total throughput of an arithmetic circuit.

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**3**	**2**	**3**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**3**	**1**
2	CO2	**3**	**2**	**3**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**3**	**1**
3	CO3	**3**	**2**	**3**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**3**	**1**
4	CO4	**3**	**2**	**3**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**3**	**1**
5	CO5	**3**	**2**	**3**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**3**	**1**

SYLLABUS

No.	Content	Hours	COs
I	Signed numbers: Signed-Magnitude Representation, Biased Representations, Complement Representations, Two's- and 1's-Complement Numbers, Direct and Indirect Signed Arithmetic, Using Signed Positions or Signed Digits. Redundant number systems: the Carry Problem, Redundancy in Computer Arithmetic, Digit Sets and Digit-Set Conversions, Generalized Signed-Digit Numbers, Carry-Free Addition Algorithms, Conversions and Support Functions. Residue number systems: RNS Representation and Arithmetic, the RNS Moduli, Difficult RNS Arithmetic Operations, Redundant RNS Representations, Limits of Fast Arithmetic in RNS.	**08**	**CO1**
II	Fast Addition and subtraction: Simple Carry-Skip Adders, Multilevel Carry-Skip Adders, Carry-Select Adders, Conditional-Sum Adder, Hybrid Adder Designs, Optimizations in Fast Adders. Multioperand addition: Using Two-Operand Adders, Carry-Save Adders, Wallace and Dadda Trees, Parallel Counters, Generalized Parallel Counters, Adding Multiple Signed Numbers.	**08**	**CO2**
III	Fast multipliers: Radix-4 Multiplication, Modified Booth's Recoding, Using Carry-Save Adders, Radix-8 and Radix-16 Multipliers. Tree and array multipliers: Full-Tree Multipliers, Alternative Reduction Trees, Tree Multipliers for Signed Numbers, Partial-Tree Multipliers, Array Multipliers, Pipelined Tree and Array Multipliers. Variations in multipliers: Divide-and-Conquer Designs, Additive Multiply Modules, Bit-Serial Multipliers, Modular Multipliers, The Special Case of Squaring, Combined Multiply-Add Units.	**09**	**CO3**
IV	Fast Dividers: Basics of High-Radix Division, Radix-2 SRT Division, Using Carry-Save Adders, Choosing the Quotient Digits, Radix-4 SRT Division, General High-Radix Dividers. Division by convergence: General Convergence Methods, Division by Repeated Multiplications, Division by Reciprocation, Speedup of Convergence Division, Hardware Implementation, Analysis of Lookup Table Size.	**07**	**CO4**
V	High-throughput arithmetic: Pipelining of Arithmetic Functions, Clock Rate and Throughput, Parallel and Digit-Serial Pipelines, On-Line or Digit-Pipelined Arithmetic. Low-power arithmetic: The Need for Low-Power Design, Sources of Power Consumption, Reduction of Power Waste, Transformations and Trade-Offs, Some Emerging Methods	**07**	**CO5**
	Total Hours	**39**	

Essential Readings:

1. Behrooz Parhami, "Computer Arithmetic: Algorithms and Hardware Designs", 1st ed., 2000, Oxford university press.
2. Mi Lu., "Arithmetic and logic in computer systems", 1st ed., 2004, John Wiley and Sons.
3. Paul Zimmermann and Richard Brent, "Modern Computer Arithmetic", 1st ed. 2010, Cambridge university press.

Supplementary Readings:

1. Donald e. Knuth., "The art of computer programming", 2nd ed., 1985, Addison-Wesley publishing company.
2. M Ercegovac, T Lang, "Digital Arithmetic", Hardware and Programming", 1st ed., 2004, Morgan Kaufmann publishers.
3. Israel Koren, "Computer Arithmetic Algorithms", 2nd ed., 2002, A.K. Peters.

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CURRICULUM

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-2020**
Department	**Computer Science and Engineering**	Semester	**V**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS 371	**Database System Concepts**	**2**	**0**	**0**	**2**	**50**	**50**	**100**	**200**

Course Objectives

- **To understand the fundamentals concepts of database, operation of relational data model and its requirement in an organization.**
- **To understand the various relational data models, application of relational data models to design logical database including E-R diagrams and database normalization. And also write the simple and optimized advanced database queries using Structured Query Language (SQL).**
- **To develop and ability to design and implement a small database project using Structured Query Language (SQL).**
- **To understand the requirement of database tuning, concept of a database transaction, including concurrency control, data object locking protocols and role of database administrator.**

Course Outcomes

CO1	**Able to describe the fundamental components of database systems, Relational Database Management System and its need towards an organization.**
CO2	**Able to demonstrate the Entity Relationship Model, analyse the real world problems and requirements, to give the appropriate solution using the principles of Entity Relationship Diagram.**
CO3	**Able to attain the practical understanding of SQL, convert the Entity relationship model to relational tables, operations to store the data using queries.**
CO4	**Able to apply the principles of normalization to remove the redundancy and inconsistency to improve the performance.**
CO5	**Able to understand the concurrent transactions, Problems such as failures, solutions to solve the concurrency problems using protocols**

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	3	3	0	0	0	0	0	0	2	0	0	0	3	0	3
2	CO2	3	3	3	1	2	0	0	0	1	0	0	0	2	3	2
3	CO3	1	2	3	3	2	2	0	0	0	0	0	0	2	3	3
4	CO4	1	2	3	3	3	2	3	0	2	0	0	1	2	3	2
5	CO5	2	3	3	2	2	3	2	0	2	0	0	1	3	3	3

SYLLABUS

No.	Content	Hours	COs
I	**Introduction to Database: Purpose of database systems, data abstraction and modelling, instances and schemes, database manager, database users and their interactions, data definition and manipulation language, data dictionary, overall system structure.**	**02**	**CO1** **CO2**
II	**Entity-relationship model:** **Entities and entity sets, relationships and relationship sets, mapping constraints, E-R diagram, primary keys, strong and weak entities, reducing E-R diagrams to tables, trees or graphs, generalization and specialization, aggregation.**	**04**	**CO1** **CO2**
III	**Relational model:** **Structure of a relational database, operation on relations, relational algebra, tuple and domain relational calculus, salient feature of a query language, Structured query language: Description an actual RDBMS and SQL.**	**07**	**CO2** **CO3** **CO4**
IV	**Normalization:** **Pitfalls in RDBMS, importance of normalization, functional, multi-valued and join dependencies, 1NF to 5NF, limitations of RDBMS.**	**05**	**CO4** **CO5**
V	**Concurrency Control in RDBMS:** **Testing for serializability, lock based and time-stamp based protocols; Deadlock detection and Recovery**	**06**	**CO4** **CO5**
	Total	**24**	

Essential Readings

1. Silberschatz, Korth and Sudarshan, Database system concepts, McGraw Hill, 7th Edition, 2019.
2. C.J. Date, An Introduction to Database Systems (8th Edition), Pearson, 8th Edition, 2004.
3. Steven Feuerstein, Bill Pribyl, “Oracle PL/SQL Programming,”, O'Reilly Media, 6th Edition, 2014.

Supplementary Readings

1. Elmasri and Navathe, Fundamentals of database systems; Pearson, 7th Edition, 2016.
2. Raghu Ramakrishnan and Gehrke, Database Management System, McGraw-Hill, 3rd Edition, 2014.
3. C. J. Date, SQL and Relational Theory: How to Write Accurate SQL Code, O'Reilly Media, 3rd Edition, 2015.

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Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-20**
Department	**Computer Science and Engineering**	Semester	**V**

Course Code	Course Name	Credit Structure				Marks Distribution		
		L	T	P	C	Continuous Evaluation	Lab Test/ Viva	Total
CS351	**Operating Systems Lab**	**0**	**1**	**2**	**2**	**70**	**30**	**100**

Course Objectives		Course Outcomes		
	To introduce the components of operating system		CO1	**Able tolearn the fundamentals of Operating Systems**
	To analyse the process scheduling and execution		CO2	**Able to acquire knowledgeabout different process scheduling techniques.**
	To describe the structure of main memory, virtual memory		CO3	**Able to solve process synchronization and deadlock handling strategies**
	To describe the function of file systems		CO4	**Able to acquire knowledgeabout different memory management techniques and page replacementalgorithms.**

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**0**
2	CO2	**2**	**1**	**1**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**1**	**2**	**1**	**1**
3	CO3	**2**	**2**	**2**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**1**	**1**
4	CO4	**2**	**2**	**2**	**2**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**1**	**1**	**1**	**1**

SYLLABUS

No.	Content	Hours	COs
I	**Basic Commands of UNIX, Shell Programming,Implementation of CPU scheduling algorithms, Performance Comparison of CPU scheduling algorithms. Implementation of IPC.**	**12**	**CO1 CO2 CO3 CO4**
II	**Implementation of Peterson's Solution, Semaphores, Monitors**	**06**	
III	**Classical Process Coordination & Synchronization Problems like, Bounded Buffer, Producer-Consumer,Readers-Writers, Dinning philosophers, The Cigarette-Smokers Problem, Dining-Philosophers Solution Using Monitors**	**10**	
IV	**Implementation of Deadlock Avoidance Algorithms, Detection Algorithms**	**04**	
V	**Implementation of contiguous memoryallocation techniques, Paging Techniques, Page Replacement Algorithms, Disk Scheduling Algorithms**	**04**	
	To be done necessarily as mini-project group-wise in groups of at least two/three students.		
	Total Hours	**36**	

Essential Readings

1. Abraham Silberschatz, Peter Baer Galvin, Greg Gagne, "Operating System Concepts", 9th Edition, John Wiley & Sons Inc. 2012.
2. Andrew S Tanenbaum, "Modern Operating Systems", 4th Edition, Prentice Hall. 2014
3. William Stallings, "Operating System: Internals and Design Principles", 9th Edition, Pearson, 2018.

Supplementary Readings

1. Harvey M. Deitel, Paul J. Deitel, David R. Choffnes, "Operating System", 3rd Edition, Pearson, 2013.
2. D M Dhamdhere, "System Programming and Operating Systems", 2nd Edition, Tata McGraw Hill, 2009.
3. Gary Nutt, " Operating Systems: A Modern Perspective", 2nd Edition, Addison Wesley, 2001.
4. Achyut S Godbole, "Operating Systems", 3rd Edition, Tata McGraw Hill, 2010.

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Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-2020**
Department	**Computer Science and Engineering**	Semester	**V**

Course Code	Course Name	Credit Structure				Marks Distribution		
		L	T	P	C	Continuous Assessments	Quiz / Viva	Total
CS 353	**Database Management Systems Lab**	**0**	**1**	**2**	**2**	**70**	**30**	**100**

Course Objectives	Course Outcomes		
To understand the concept of Database Management System in practical view and software specific tools for information processing oriented framework.		CO1	**Able to understand and demonstrate the real time challenges in the Database Management Systems, components of various software tools.**
To understand and demonstrate the E-R data model in formal way and implementation of relational data model (E-R data model) in relational data model using query and procedure.		CO2	**Able to design, Normalize, and implement the database schema for the given problems.**
To understand the real time problem, design an application as the developer to accomplish the given task.		CO3	**Able to construct the query using the SQL commands i.e. DDL/DML, declare and keep the integrity constraints on the developing database using the concept of Relational Database Management System.**
To understand and implement JDBC/ODBC concept for the operations for the developing database, Concurrent transaction processing and recovery in multiuser database environment.		CO4	**Able to improve the performance of query and write the programming SQL such as stored procedure, cursor, stored functions.**
		CO5	**Able to design and develop the graphical user interface application using fourth generation language to access the database.**

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	3	3	0	0	0	0	0	0	2	0	0	0	3	0	3
2	CO2	3	3	3	1	2	0	0	0	1	0	0	0	2	3	2
3	CO3	1	2	3	3	2	2	0	0	0	0	0	0	2	3	3
4	CO4	1	2	3	3	3	2	3	0	2	0	0	1	2	3	2
5	CO5	2	3	3	2	2	3	2	0	2	0	0	1	3	3	3

SYLLABUS

No.	Content	Hours	COs
I	Assignment on Entity Relationship modeling of real world problems.	**02**	**CO1**
II	Assignment on creating relational databases with simple tables	**02**	**CO1** **CO2**
III	Assignment on implementation of indexing structures	**02**	**CO1** **CO2**
IV	Assignment on creating databases with indexing structures	**02**	**CO3**
V	Assignment on implementing SQL queries	**02**	**CO3**
VI	Assignment on creating views and queries based on views	**02**	**CO3** **CO4**
VII	Assignment on write SQL queries using logical operations (=,<,>,etc)	**02**	**CO3** **CO4**
VIII	Assignment on implementing embedded SQL queries	**02**	**CO4**
IX	Assignment on PL/SQL	**02**	**CO4**
X	Assignment on check pointing and recovery	**02**	**CO4**
XII	Assignment on implementing multi-user database.	**02**	**CO5**
XII	Mini Project using the selected RDBMS and front end tools.	**02**	**CO5**
	Total	**24**	

Essential Readings

1. Silberschatz, Korth and Sudarshan, Database system concepts, McGraw Hill, 7th Edition, 2019.
2. C.J. Date, An Introduction to Database Systems (8th Edition), Pearson, 8th Edition, 2004.
3. Steven Feuerstein, Bill Pribyl, “Oracle PL/SQL Programming,”, O'Reilly Media, 6th Edition, 2014.

Supplementary Readings

1. Elmasri and Navathe, Fundamentals of database systems; Pearson, 7th Edition, 2016.
2. Raghu Ramakrishnan and Gehrke, Database Management System, McGraw-Hill, 3rd Edition, 2014.
3. C. J. Date, SQL and Relational Theory: How to Write Accurate SQL Code, O'Reilly Media, 3rd Edition, 2015.

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Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-20**
Department	**Computer Science and Engineering**	Semester	**V**

Course Code	Course Name	Credit Structure				Marks Distribution		
		L	T	P	C	Continuous Evaluation	Quiz / Viva	Total
CS 355	**Computer Networks Lab**	**0**	**0**	**2**	**1**	**70**	**30**	**100**

Course Objectives		Course Outcomes		
	To develop the student's ability to understand the basic concept of networking, packet switching and circuit switching etc.		CO1	**Able to understand the brief of internet and also the concept of circuit switching and packet switching.**
	To develop the student's ability to understand the application layer of the network model along with the ability to perform socket programming.		CO2	**Able to understand the purpose of application layer and various application layer protocols such as DNS, FTP, SMTP.**
	To provide the students with some knowledge and analysis skills associated with transport layer protocols TCP and UDP.		CO3	**Able to understand various transport layer protocol like UDP, TCP, and various mechanisms to control TCP congestion.**
	To develop the student's ability to understand the network layer of network model like IPv4 addressing NAT etc.		CO4	**Able understand the IPV4 addressing and forwarding mechanism and solve relevant problems.**

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**2**	**0**	**0**	**0**	**0**	**1**	**0**	**2**	**0**	**0**	**0**	**2**	**1**	**1**	**1**
2	CO2	**2**	**2**	**2**	**1**	**2**	**0**	**0**	**2**	**0**	**2**	**0**	**1**	**2**	**2**	**1**
3	CO3	**3**	**2**	**2**	**3**	**0**	**0**	**2**	**1**	**0**	**1**	**1**	**1**	**2**	**1**	**1**
4	CO4	**1**	**1**	**0**	**1**	**0**	**0**	**0**	**2**	**1**	**1**	**0**	**2**	**3**	**1**	**3**

Suggested List of Experiments

No.	Content	Hours	COs
I	Assignment on Error Detection using Single Parity Check	**02**	**CO1**
II	Assignment on Error Detection using CRC	**02**	**CO1**
III	Assignment on Error Detection using Checksum	**02**	**CO1**
IV	Assignment on UDP Socket Programming – UDP Echo	**02**	**CO2, CO3, CO4**
V	Assignment on TCP Socket Programming – Client and Server both in same machine	**02**	**CO2, CO3, CO4**
VI	Assignment on TCP Socket Programming – Client and Server in different machines	**02**	**CO2, CO3, CO4**
VII	Assignment on TCP Socket Programming – Students' Database	**02**	**CO2, CO3, CO4**
VIII	Assignment on TCP Socket Programming – English Dictionary	**02**	**CO2, CO3, CO4**
IX	Assignment on TCP Socket Programming – Involving Files	**02**	**CO2, CO3, CO4**
X	Assignment on TCP Socket Programming – Upload and Download	**02**	**CO2, CO3, CO4**
	Total Hours	**20**	

Essential Readings

1. J. F. Kurose, K. W. Ross, "Computer Networking: A Top-Down Approach", Pearson Publication, 6th Edition, 2013.
2. B. Forouzan, "Data Communication and Networks", McGraw-Hill Publication, 5th Edition, 2012.
3. A. S. Tanenbaum, D. J. Wetherall, "Computer Networks", Pearson Publication, 5th Edition, 2011.

Supplementary Readings

1. W. Stalling, "Data and Computer Communications", Pearson Publication, 8th Edition, 2007.
2. L. L. Peterson, B. S. Davie, "Computer Networks: A Systems Approach", Morgan Kaufmann Publishers, 5th Edition, 2012.
3. A. L. Garcia and I. Widjaja, "Communication Networks Fundamental Concepts and Key Architectures", Tata McGraw-Hill Publication, 2nd Edition, 2004.

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Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-20**
Department	**Computer Science and Engineering**	Semester	**VI**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS302	**Software Engineering**	**3**	**1**	**0**	**4**	**50**	**50**	**100**	**200**

Course Objectives	Course Outcomes	
To introduce the Software Development life cycles Models	CO1	**Able to identify, formulate, and solve complex engineering problems**
To analyse the software requirements	CO2	**Able to recognize ethical and professional responsibilities in engineering situations**
To introduce various design methods for software Development	CO3	**Able to analyze, design, verify, validate, implement, apply, and maintain software systems**
To develop an ability and skill to test software systems	CO4	**Able to work in one or more significant application domain**

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**
2	CO2	**2**	**1**	**1**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**1**	**2**	**1**	**1**
3	CO3	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**
4	CO4	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**1**	**1**	**1**	**1**

SYLLABUS

No.	Content	Hours	COs
I	**Introduction** **Software process - software development life cycle models.**	**04**	**CO1**
II	**Software Requirement and Analysis** **Techniques: feasibility analysis, requirements elicitation, validation, rapid prototyping, OO paradigms vs. structured paradigm - OO analysis.**	**06**	**CO2**
III	**Software Specifications** **Specification document, specification qualities, uses, system modelling: context, interaction, structural, behavioural, DFD, specification techniques using UML, ER diagrams, logic, algebraic specifications: comparison of various techniques, formal specifications – model checking, introduction to binary decision diagrams.**	**14**	**CO2** **CO3**
IV	**Object Oriented Methodology** **Introduction to objects, relationships, unified approach to modelling, use-case modelling, activity, state and interaction diagrams, classification approaches, cohesion, coupling, reuse, case studies - object oriented paradigm, software design: architectural - distributed - data oriented design & object oriented design - real-time systems design techniques.**	**12**	**CO2** **CO3**
V	**Stepwise Refinement** **Stepwise refinement, software versions and configuration control.**	**04**	**CO1** **CO4**
VI	**Software Testing & Evolution** **Verification & validation – non-execution based testing – software inspections, code reviews, code walkthroughs – automated static analysis – Clean room software development – quality issues – execution based testing – module test-case selection, testing process: black-box, white-box, unit, integration.**	**08**	**CO3** **CO4**
Total Hours		**48**	

Essential Readings

1. Roger S Pressman: “Software Engineering – A Practitioner’s Approach”, 7th Edition, McGraw-Hill, 2009.
2. Rajib Mall, “Fundamentals of Software Engineering”, 5th Edition, PHI, 2018.
3. Ian Sommerville: “Software Engineering”. 9th Edition, Pearson Education, 2011.

Supplementary Readings

1. S.L. Pfleeger, Software Engineering – Theory and Practice, 2nd Edition, Pearson Education, 2015.
2. Paul Ammann, and Jeff Offutt, “Introduction to Software Testing”, 1st Edition, Cambridge University Press, 2008.
3. Eric Gamma, “Design Patterns: Elements of Reusable Object-Oriented Software”, 1st Edition, Addison-Wesley Longman Publishing, 1995.

	National Institute of Technology Meghalaya An Institute of National Importance	**CURRICULUM**

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2020-21**
Department	**Computer Science and Engineering**	Semester	**VI**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS 304	**Compiler Design**	**3**	**1**	**0**	**4**	**50**	**50**	**100**	**200**

Course Objectives	The Objectives of this course is to explore the principles, algorithms, and data structures involved in the design and construction of compilers.	Course Outcomes	CO1: Specify and analyse the lexical, syntactic and semantic structures of any computer programming language. CO2: Separate the lexical, syntactic and semantic analysis into meaningful phases for a compiler to undertake language translation. CO3: Write a scanner, parser, and semantic analyser for limited form of C like programming languages. CO4: Convert source code in simple language into machine code for a novel computer. CO5: Describe techniques for intermediate code and machine code optimisation. CO6: Design the structures and support required for compiling advanced language features.
	To discuss context-free grammars, and front-end phases of a compiler: lexical analysis, parsing techniques, symbol tables, error recovery.		
	To discuss back-end phases of a compiler: code generation, and different code optimization techniques.		

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**3**	**2**	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**2**
2	CO2	**3**	**3**	**3**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**1**	**3**
3	CO3	**2**	**3**	**3**	**1**	**3**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**1**	**3**
4	CO4	**2**	**1**	**1**	**2**	**2**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**1**	**3**
5	CO5	**2**	**1**	**2**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**3**
6	CO6	**2**	**2**	**2**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**1**	**3**

SYLLABUS

No.	Content	Hours	COs
I	Introduction to Compiler, Phases and passes,	**02**	**CO1**
II	Finite state machines and regular expressions and their applications to lexical analysis, Implementation of lexical analyzers, lexical-analyzer generator, LEX-compiler: LEX/FLEX,	**06**	**CO1, CO2, CO3**
III	Formal grammars and their application to syntax analysis, BNF notation, ambiguity, YACC. The syntactic specification of programming languages: Context free grammars, derivation and parse trees, capabilities of CFG. Basic Parsing Techniques: Parsers, Shift reduce parsing, operator precedence parsing, top down parsing, predictive parsers Construction of efficient Parsers: LR parsers, the canonical Collection of LR(0) items, Constructing SLR parsing tables, constructing Canonical LR parsing tables, Constructing LALR parsing tables, Using ambiguous grammars, an automatic parser generator, implementation of LR parsing tables, constructing LALR sets of items.	**16**	**CO1, CO3**
IV	Syntax-directed Translation: Syntax-directed Translation schemes, Implementation of Syntax directed Translators, Intermediate code, postfix notation, Parse trees & syntax trees, three address code, quadruple & triples, Translation of assignment statements, Boolean expressions, statements that alter the flow of control, Postfix translation, translation with a top down parser. More about translation: Array references in arithmetic expressions, procedures call, declarations, case statements. Symbol Tables: Data structure for symbols tables, representing scope information.	**13**	**CO4,CO5**
V	Run-Time Administration: Implementation of simple stack allocation scheme, Storage allocation in block structured language. Error Detection & Recovery: Lexical Phase errors, syntactic phase errors semantic errors.	**11**	**CO1, CO6**

	Introduction to code optimization: Loop optimization, DAG representation of basic blocks, Value numbers and algebraic laws, Global Data-Flow analysis.		
Total Hours		**48**	

Essential Readings:

1. A.V. Aho, M. S. Lam, R. Sethi and J. D. Ullman, "Compilers-Principles, Techniques and Tools", 2nd ed., 2006, Pearson Education.
2. K. Muneeswaran, "Compiler Design", 1st ed., 2013, Oxford Publication.
3. P.H. Dave, H.B. Dave, "Compilers: Principles and Practice", 1st ed. 2012, Pearson Education.

Supplementary Readings:

1. Allen I. Holub, "Compiler Design in C", 1st ed.(Indian print), 2012, PHI.
2. John Levine, "Flex & Bison ", 1st ed., 2009, O'reilly.
3. Torben Ægidius Mogensen, "Basics of Compiler Design", 1st ed., 2007, DIKU, University of Copenhagen

	National Institute of Technology Meghalaya An Institute of National Importance	CURRICULUM

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-20**
Department	**Computer Science and Engineering**	Semester	**VI**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS 312	**Computer Graphics**	**3**	**0**	**0**	**3**	**50**	**50**	**100**	**200**

Course Objectives

1. To introduce the use of the components of a graphics system and become familiar with building approach of graphics system components and algorithms related with them.
2. To introduce the mathematical foundation of computer graphics like the basic principles of 2D and 3D concept of computer graphics.
3. To introduce Color perception, color models (RGB model), color transformations.
4. To provide an understanding of how to scan convert the basic geometrical primitives, how to transform the shapes to fit them as per the picture definition.
5. Provide an understanding of mapping from a world coordinates to device coordinates, clipping, and projections.
6. To be able to discuss the application of computer graphics concepts in the development of computer games, information visualization, and business applications.

Course Outcomes

CO1	Able to acquire knowledge about the basic concepts used in computer graphics
CO2	Able to interpret the mathematical foundation of the concepts like 2D and 3D geometrical concepts of computer graphics.
CO3	Able to implement various algorithms to scan, convert the basic geometrical primitives, transformations, Area filling, clipping.
CO4	Able to describe the importance of viewing and projections.
CO5	Students will be able to acquire knowledge about rasterization: line drawing via Bresenham's algorithm, clipping, polygonal fill etc.
CO6	Students will be able to understand a typical graphics pipeline and 3D modelling.

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**2**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**3**	**0**	**3**
2	CO2	**1**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**2**	**0**	**2**
3	CO3	**1**	**2**	**3**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**3**	**2**
4	CO4	**0**	**2**	**3**	**0**	**2**	**2**	**3**	**0**	**2**	**0**	**0**	**1**	**2**	**3**	**2**
5	CO5	**0**	**2**	**3**	**0**	**2**	**2**	**0**	**0**	**2**	**0**	**0**	**1**	**3**	**3**	**3**
6	CO6	**0**	**0**	**1**	**2**	**0**	**0**	**0**	**0**	**1**	**0**	**2**	**1**	**2**	**2**	**0**

SYLLABUS

No.	Content	Hours	COs
I	Introduction Graphic areas, Major Applications, Graphic APIs, 3D Geometric Models, Graphics Pipeline, Numerical Issues, Efficiency	08	CO1 CO2
II	Miscellaneous Math Sets and Mappings, Solving Quadratic Equations, Trigonometry, Vectors, 2D Implicit and Parametric Curves, 3D Implicit and Parametric Curves, Linear Interpolation, Determinants and Matrices, Basic 2D and 3D transforms, Inverses of Transformation Matrices.	08	CO2 CO3
III	Raster Algorithms Raster Displays, Monitor Intensities, RGB color, Line Drawing, Simple Anti-aliasing, Image Capture and Storage, Graph Algorithms	05	CO2 CO3
IV	Ray Tracing The basic Ray Tracing Algorithm, Computing Viewing Rays, Ray-Object Intersection, A Ray Tracing Program, Shadows, Specular Reflection, Refraction, Instancing, Constructive Solid Geometry, Distribution Ray Tracing.	03	CO4 CO3 CO4
V	Data Structures for Graphics Triangle Meshes, Winged Edge Data Structure, Scene Graphs, Scene Graphs, Tiling Multidimensional Arrays.	04	CO4 CO5
VI	Sampling Integration, Continuous Probability, Monte Carlo Integration, Choosing Random Points.	08	CO5 CO6
VII	Reflection Models Real World Materials, Implementing Reflection Models. Specular Reflection Material, Smooth Layered Model, Rough Layered Model.	04	CO6
	Total Hours	40	

Essential Readings

1. Computer Graphics: Principles and Practice in C (3rd Edition), by James D. Foley, Andries van Dam, Steven K. Feiner, John F. Hughes, 2014.
2. Fundamentals of Computer Graphics, by Peter Shirley, Michael Ashikhmin, Steve Marschner, A K Peters/CRC Press; 3 edition, 2009.
3. Computer Graphics, C Version (2nd Edition) by Donald Hearn, M. Pauline Baker, Prentice Hall; 1996.

Supplementary Readings

1. Introduction to Computer Graphics, David J. Eck, Hobart and William Smith Colleges, Copyright Year: 2016, Publisher: David J. Eck.
2. Computer Graphics: using OpenGL / F.S. Hill, Jr., Prentice Hall ; 2001.
3. Interactive computer graphics: data structures, algorithms, languages, By W. K. Giloi, Prentice-Hall, 1989.

	National Institute of Technology Meghalaya An Institute of National Importance	**CURRICULUM**

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-20**
Department	**Computer Science and Engineering**	Semester	**VI**

Course Code	Course Name	Pre-Requisite	Credit Structure				Marks Distribution			
			L	T	P	C	INT	MID	END	Total
CS 314	**Shell Programming**	**None**	**3**	**0**	**0**	**3**	**50**	**50**	**100**	**200**

Course Objectives	To introduce basic concepts and principles of command line programming, the command structure, the types of commands, and the categorizations of commands for different operating systems.	Course Outcomes	**CO1**	Able to discuss the basic concepts and principles of command line programming, the command structure, the types of commands, and the categorizations of commands for different operating systems.
	To develop the skills for shell programming in different operating systems.		**CO2**	Able to use general commands, file and directory handling commands, process handling commands, network communication and user communication/ interaction related commands, some system administration related commands, and some special commands.
	To introduce several commands for working in different shells of different operating systems.		**CO3**	Able to familiarize with different shells for different operating systems, different text editors available in Unix - like operating systems for shell programming, working on the vi editor, and writing various shell scripts and windows bat scripts for simple applications.
			CO4	Able to use decision control, looping, different data types, functions and other programming features in shell programming.
			CO5	Able to use filters, piping and regular expressions in shell programming.

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**3**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**1**	**1**	**1**
2	CO2	**3**	**1**	**2**	**1**	**1**	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**2**	**2**	**0**
3	CO3	**3**	**2**	**3**	**1**	**2**	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**3**	**2**	**0**
4	CO4	**3**	**2**	**2**	**1**	**2**	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**3**	**2**	**0**
5	CO5	**3**	**1**	**2**	**1**	**2**	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**3**	**2**	**0**

SYLLABUS

No.	Content	Hours	COs
I	Command structure for Unix - like and Windows operating systems (OSs); Command Line Interface (CLI) vs. Graphical User Interface (GUI); CLIs in different OSs: popular shells for Unix - like OSs, MS-DOS command.com shell, Windows Command Prompt, Windows Powershell; Types of CLI commands: internal and external commands for different OSs	**03**	**CO1**
II	Different commands in Unix/ Linux and Windows OSs: Simple Unix/ Linux commands, Simple Windows commands; file and directory handling utilities; process handling commands; network communication and user communication/ interaction related commands; system administration commands; special commands	**12**	**CO1, CO2**
III	Introduction to shells in different operating systems: Korn shell, Bash shell, C shell, Windows Command Prompt, Powershell; text editors in Unix - like operating systems; working on the vi editor; creating shell scripts in Unix/ Linux, creating bat files in Windows OSs; examples of shell scripts, bat scripts and powershell scripts	**08**	**CO1, CO3**
IV	Different programming features for shell programming in Unix/ Linux and Windows OSs:- decision control; looping; use of different data types: variables, arrays, files; use of functions; examples of shell scripts, bat scripts and powershell scripts	**12**	**CO4**
V	Other important concepts in shell programming in Unix/ Linux and Windows OSs:- use of filters; use of piping (redirection); use of regular expressions; examples of shell scripts, bat scripts and powershell scripts	**05**	**CO5**
Total Hours		**40**	

Essential Readings

1. Behrouz A. Forouzan, Richard F. Gilberg, “Unix and Shell Programming: A Textbook”, Cengage Learning, first edition, 2003.
2. Sumitabha Das, “Your UNIX/Linux: The Ultimate Guide”, McGraw-Hill Education, third edition, 2012.
3. Bruce Payette, Richard Siddaway, “Windows PowerShell in Action, Manning publications, third edition, 2017.

Supplementary Readings

1. Graham Glass, King Ables, “UNIX for Programmers and Users”, Pearson Education India, third edition, 2003.
2. Yashavant Kanetkar, “Unix Shell Programming”, BPB publications, first edition, 2003.
3. Lee Holmes, “Windows PowerShell Cookbook”, O’reilly Media, third edition, 2013.

National Institute of Technology Meghalaya

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CURRICULUM

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-20**
Department	**Computer Science and Engineering**	Semester	**VI**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS316	**Augmented and Virtual Reality**	**3**	**0**	**0**	**3**	**50**	**50**	**100**	**200**

Course Objectives		Course Outcomes		
	To understand the basic concepts of augmented and virtual reality		CO1	**Able to analyse the components of Virtual Reality**
	To apply the various concepts of virtual reality.		CO2	**Able to assess and compare technologies of Virtual Reality**
	To explore the application area of augmented and virtual reality		CO3	**Able to design application of Virtual Reality**

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**
2	CO2	**1**	**1**	**2**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**1**	**1**	**1**	**1**
3	CO3	**1**	**1**	**1**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**

SYLLABUS

No.	Content	Hours	COs
I	**Introduction** **The historical development of Virtual Reality, Fundamental concept and components of Virtual Reality, Primary features and present development on Virtual Reality, Virtual environment, Requirements of Virtual Reality**	**08**	**CO1**
II	**3D User Interface Input/output Hardware** **Input Device Characteristics, Desktop Input Devices, Tracking Devices, 3D Mice, Special-Purpose Input Devices, Direct Human Input, Choosing Input Devices for 3D Interfaces, Visual Displays, Auditory Displays, Haptic Displays, Choosing Output Devices for3D User Interfaces**	**10**	**CO1**
III	**3D Interaction Techniques** **Representation of the Virtual Worldand Rendering Systems- Visual Representation, Aural Representation, Haptic Representation, Manipulating a Virtual World, Navigating in a Virtual World, Wayfinding - Theoretical Foundations, User-CenteredWayfinding Support, Environment-CenteredWayfinding Support, Design Guidelines**	**10**	**CO2**
IV	**Applications** **What makes an application a good candidate for Virtual Reality, Business and manufacturing, Science, Medical, Education, Public Safety and Military, Entertainment**	**08**	**CO3**
	Total Hours	**36**	

Essential Readings

1. Doug A Bowman, Ernest Kuijff, Joseph J LaViola, Jr and Ivan Poupyrev, “3D User Interfaces, Theory and Practice”, 1st Edition, AddisonWesley, USA, 2005.
2. William R Sherman and Alan B Craig, “Understanding Virtual Reality: Interface, Application and Design”, 1st Edition, Morgan Kaufmann Publishers, San Francisco, CA, 2002.
3. Alan B Craig, William R Sherman and Jeffrey D Will, “Developing Virtual Reality Applications: Foundations of Effective Design”, 2nd Edition Morgan Kaufmann, 2009.

Supplementary Readings

1. Burdea, Grigore C and Philippe Coiffet, “Virtual Reality Technology”,1st Edition, Wiley Interscience, India, 2003.
2. John Vince, “Virtual Reality Systems”, 1st Edition, Addison Wesley, 1995.
3. Oliver Bimber, Ramesh Raskar, “Spatial Augmented Reality Merging Real and Virtual Worlds”, 1st Edition, CRC Press, 2005.

	National Institute of Technology Meghalaya An Institute of National Importance	CURRICULUM

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-20**
Department	**Computer Science and Engineering**	Semester	**VI**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS318	**Information Theory and Coding**	**3**	**0**	**0**	**3**	**50**	**50**	**100**	**200**

Course Objectives		Course Outcomes		
	To develop the student's ability to understand the concept of information theory.		CO1	**Able to acquire knowledge about concept of mutual information and entropy in information theory.**
	To provide the students about various codes used for data compression.		CO2	**Able to acquire knowledge about various data compression codes**
	To develop the student's ability to analyse the error correcting codes used for reliable transfer of data.		CO3	**Able to understand and analyse the various error correcting codes used for reliable transfer of data.**
	To familiarize the student with the various decoding techniques.		CO4	**Able to understand and analyse the decoding techniques.**
	To familiarize the student the cryptographic algorithms used in information theory.		CO5	**Able to understand and analyse some of the cryptographic algorithms used in information theory.**

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**3**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**3**
2	CO2	**3**	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**1**	**0**	**3**	**2**	**2**
3	CO3	**3**	**3**	**3**	**1**	**2**	**0**	**2**	**0**	**2**	**0**	**0**	**0**	**3**	**3**	**2**
4	CO4	**2**	**3**	**3**	**1**	**2**	**2**	**2**	**0**	**2**	**0**	**1**	**1**	**2**	**2**	**3**
5	CO5	**2**	**3**	**3**	**1**	**2**	**2**	**2**	**0**	**2**	**0**	**3**	**1**	**1**	**2**	**3**

SYLLABUS

No.	Content	Hours	COs
I	Uncertainty, Information, Concept of mutual information, Entropy and their properties, Channel Capacity, Shannon's Theorems, Gaussian Channel	**06**	**CO1**
II	Noiseless coding, Huffman coding and its optimality, Kraft and McMillan's inequality, Shannon-Fano code, Elias code, Arithmetic coding and universal coding.	**10**	**CO2**
III	Algebraic codes-Linear Block codes, Cyclic codes-BCH codes, perfect code, galley codes, Finite geometry codes, Hadamard codes, Maximal distance separable codes, sphere packing and singleton bounds. Codes for random access memories, tapes and disc, fault tolerant computation with arithmetic codes and redundant number systems.	**10**	**CO3**
IV	Exact techniques of decoding, relationship between complexity of algorithms in poly-digital circuits and VLSI with algebraic coding.	**07**	**CO4**
V	Cryptographic codes-Random number generation, DES scheme, RSA scheme and Diffie & Hellman's Public Key Crypto systems.	**07**	**CO5**
Total Hours		**40**	

Essential Readings

1. Blahut, R.E, Theory and practice of error control codes, Addison Wesley, 1st Edition, 1983, reprint 1992.
2. Blahut, R.E, Principles of transmission of digital information, Addison Wesley, 1st Edition, 1990.
3. Behrouz A. Forouzan, "Cryptography and Network Security", McGraw-Hill publication, 2nd Edition, 2010.

Supplementary Readings

1. James V Stone, Information Theory: A Tutorial introduction, Sebtel Press, 1st Edition, 2015.
2. Thomas M Cover and Joy A Thomas, Elements of Information Theory, Wiley India, 2nd Edition, 2006.
3. Jorge Castiñeira Moreira, Patrick Guy Farrell , Essentials of Error-Control Coding, Wiley, 1st Edition, 2006.

	National Institute of Technology Meghalaya An Institute of National Importance	**CURRICULUM**

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-20**
Department	**Computer Science and Engineering**	Semester	**VI**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS 320	**Machine Learning**	**3**	**0**	**0**	**3**	**50**	**50**	**100**	**200**

Course Objectives	Course Outcomes		
To understand the different learning models and its usage in computer vision and data analytics.		CO1	Able to identify potential applications of machine learning in practice
To understand the different classification algorithms and its application in image understanding and data clustering		CO2	Able to Describe the differences in approaches and applicability of regression, classification, and clustering
To understand forecasting and different learning theory applied for prediction of desired conclusion in data analytics.		CO3	Able to use forecasting and prediction models using different learning theory
Apply different unsupervised learning and reinforcement learning models in application areas like image forgery, image classification, data clustering and decision making process		CO4	Able to select the suitable machine learning models for decision making process
To understand the dimension reduction process and handling of big data using machine learning models		CO5	Able to apply the dimension reduction process, feature selection process and use of machine learning models for big data

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**3**	**3**	**0**	**1**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**3**	**0**	**3**
2	CO2	**3**	**3**	**0**	**1**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**2**	**0**	**2**
3	CO3	**2**	**3**	**3**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**3**	**2**
4	CO4	**2**	**2**	**3**	**0**	**2**	**2**	**3**	**0**	**2**	**0**	**0**	**1**	**2**	**3**	**2**
5	CO5	**2**	**2**	**3**	**0**	**2**	**2**	**3**	**0**	**2**	**0**	**0**	**1**	**3**	**3**	**3**

SYLLABUS

No.	Content	Hours	COs
I	Introduction, Machine learning basics, Supervised Learning: Artificial Neural Network, classifying with k-Nearest Neighbour classifier, Support vector machine classifier, Decision Tree classifier, Naive Bayes classifier, Bagging, Boosting, Improving classification with the AdaBoost meta algorithm.	**10**	**CO1**
II	Forecasting and Learning Theory: Predicting numeric values: regression, Linear Regression, Logistic regression, Tree-based regression. Bias/variance tradeoff, Union and Chernoff/Hoeffding bounds, Vapnik–Chervonenkis (VC) dimension, Worst case (online) learning.	**10**	**CO2**
III	Unsupervised Learning: Grouping unlabeled items using k-means clustering, Association analysis with the Apriori algorithm, efficiently finding frequent item sets with FP-growth.	**8**	**CO1** **CO3**
IV	Reinforcement learning: Markov decision process (MDP), Bellman equations, Value iteration and policy iteration, Linear quadratic regulation, Linear Quadratic Gaussian, Q-learning, Value function approximation, Policy search, Reinforce, POMDPs.	**6**	**CO2** **CO3**
V	Dimensionality reduction: Feature extraction - Principal component analysis, Singular value decomposition. Feature selection – feature ranking and subset selection, filter, wrapper and embedded methods. Machine Learning for Big data: Big Data and MapReduce.	**06**	**CO4** **CO5**
	Total Hours	**40**	

Essential Readings

1. Title: Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Publisher: O'Reilly Media, Inc , 2nd Edition, 2019.
2. Title: Introduction to Machine Learning, Author E. Alpaydin, Publisher: MIT Press Edition, 2nd Edition, 2009.
3. Title: Machine Learning, Author: T. M. Mitchell, Publisher: McGraw-Hill, Edition 1997.

Supplementary Readings

1. Title: Machine learning in action, Author: P. Harrington, Publisher: Manning Publications, 2012 Edition.
2. Title: Pattern recognition and Machine Learning, Author C. M. Bishop, Publisher: Springer, 2007 Edition.
3. Title: Machine Learning for Big Data, Author: J. Bell, Publisher: Wiley, 2014 Edition.

	National Institute of Technology Meghalaya An Institute of National Importance	CURRICULUM

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-20**
Department	**Computer Science and Engineering**	Semester	**VI**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS322	**Cryptography and Network security**	**3**	**0**	**0**	**3**	**50**	**50**	**100**	**200**

Course Objectives	Course Outcomes		
To develop the student's ability to understand the concept of security goals in various applications.		CO1	**Able to acquire knowledge about security goals, background of cryptographic mathematics and identification of its application**
To provide the students with some fundamental cryptographic mathematics used in various symmetric and asymmetric key cryptography.		CO2	**Able to acquire knowledge about the background mathematics of symmetric key cryptography and understand, analyse and implement – the symmetric key algorithm.**
To develop the student's ability to analyse the cryptographic algorithms.		CO3	**Able to acquire knowledge about the background mathematics of asymmetric key cryptography and understand and analyse – asymmetric key encryption algorithms, digital signatures**
To familiarize the student the need of security in computer networks.		CO4	**Able to understand and analyse the concept of message integrity and the algorithms for checking the integrity of data.**
		CO5	**Able to understand and analyse the existing cryptosystem used in networking**

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**3**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**3**
2	CO2	**3**	**3**	**0**	**0**	**0**	**1**	**0**	**0**	**2**	**0**	**0**	**0**	**3**	**3**	**2**
3	CO3	**3**	**3**	**3**	**1**	**2**	**1**	**0**	**0**	**2**	**0**	**0**	**0**	**3**	**3**	**2**
4	CO4	**2**	**3**	**3**	**1**	**2**	**2**	**3**	**0**	**2**	**0**	**0**	**1**	**3**	**2**	**2**
5	CO5	**2**	**3**	**3**	**1**	**2**	**2**	**3**	**0**	**2**	**0**	**0**	**1**	**3**	**3**	**3**

SYLLABUS

No.	Content	Hours	COs
I	Introduction Security goals, cryptographic attacks. Mathematics of cryptography: modular arithmetic, Euclidean and extended Euclidean algorithm. Traditional symmetric key ciphers; Monolithic ciphers: addition and multiplication ciphers, Polyalphabetic ciphers: Vigenere's ciphers, Hill ciphers, playfair ciphers.	**08**	**CO1**
II	Symmetric key cryptography Mathematics of symmetric key cryptography: Groups, Rings, Fields, GF, Inverse of a number and polynomial using extended Euclidean algorithm. Modern Block ciphers and its components, DES, AES	**08**	**CO2**
III	Asymmetric key cryptography Mathematics of asymmetric key cryptography: Euler's Phi-Function, Fermat's Little Theorem, Euler's theorem, Chinese remainder theorem. Diffie-Hellman, Digital signature: RSA, Elgamal, Entity authentication	**08**	**CO3**
IV	Message Integrity and authentication: MAC, HMAC. Cryptographic Hash Function: Merkle-Damgard, MD5, SHA512.	**06**	**CO4**
V	Network Security Key Management, PGP, IPSec, SSL, Firewalls, Intrusion Detection, Password management, Virus. Virtual Private Network.	**10**	**CO5**
	Total Hours	**40**	

Essential Readings

1. Behrouz A. Forouzan, "Cryptography and Network Security", McGraw-Hill publication, 2nd Edition, 2010.
2. William Stallings ,"Cryptography and Network Security: Principles and Standards", Prentice Hall India, 7th Edition, 2017.
3. John R. Vacca, "Computer and Information Security Handbook", Morgan Kaufmann Publishers, 3rd Edition, 2017.

Supplementary Readings

1. Richard H. Baker, Network Security, McGraw Hill International 3rd Edition,1996.
2. B. Schneier, Applied Cryptography, John Wiley New York, 2nd Edition, 1996.
3. C. Kaufman et. al, Network Security, Prentice Hall International, 2nd Edition, 2002.

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CURRICULUM

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-20**
Department	**Computer Science and Engineering**	Semester	**VI**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS 324	**Data Analysis and Visualization**	**3**	**0**	**0**	**3**	**50**	**50**	**100**	**200**

Course Objectives	Course Outcomes	
To understand the need of data analysis and visualization techniques	CO1	**Able to analyse the different data representation and data pre-processing techniques**
To learn the different types of data analysis and visualization tools and techniques	CO2	**Able to assess and compare different data analysis and visualization techniques**
To apply the concept of data analysis and visualization to real life problems	CO3	**Able to implement data analysis and visualization based solutions for real life problems**

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**0**
2	CO2	**1**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**0**
3	CO3	**1**	**1**	**2**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**1**

SYLLABUS

No.	Content	Hours	COs
I	**Introduction** **Concepts and Need of data analysis and visualization in the era of data abundance** **Data Representation - Nominal, Binary, Ordinal, Numeric, Discrete and Continuous, Types of data - Record, Temporal, Spatial Temporal, Graph, Unstructured and Semi structured data**	**04**	**CO1**
II	**Data Statistical Properties and Data Pre-Processing** **Basic Statistical Descriptions of Data (mean, median, standard deviation, maximum, minimum, tests of significance), Probability and Random Variables, introduction to estimation theory , Correlation, Regression** **Data pre-processing- Attribute transformation, Sampling, Dimensionality reduction, Feature subset selection, Distance and Similarity calculation**	**08**	**CO1**
III	**Data Analysis Techniques** **Supervised and unsupervised learning, gradient descent, over fitting, regularization** **Unsupervised techniques - K-means, Gaussian mixture models and expectation-maximization, evaluation of clustering** **Supervised techniques - K-nearest neighbor, naive Bayes, logistic regression and Regularization, support vector machine, artificial neural networks (ANNs)**	**12**	**CO2**
IV	**Visualization and Applications** **Traditional Visualization, Multivariate Data Visualization, Principles of Perception, Color, Design, and Evaluation,** **Text Data Visualization, Network Data Visualization, Temporal Data Visualization and visualization Case Studies** **Data visualization in Python and R**	**12**	**CO2 & CO3**
Total Hours		**36**	

Essential Readings

1. Han, Jiawei, Jian Pei, and Micheline Kamber. "*Data mining: concepts and techniques"*. Elsevier, 3rd edition, 2011
2. Hastie, Trevor, Robert Tibshirani, and Jerome Friedman. "*The elements of statistical learning: data mining, inference, and prediction"*. Springer Science & Business Media, 2nd edition, 2009.
3. Embarak, Ossama. "*Data Analysis and Visualization Using Python: Analyze Data to Create Visualizations for BI Systems"*. Apress, 1st edition, 2018.

Supplementary Readings

1. Bishop, Christopher M. "*Pattern recognition and machine learning"*. springer, 1st edition, 2006.
2. Tan, Pang-Ning, Michael Steinbach, and Vipin Kumar. "*Introduction to data mining"*. Pearson Education India, 2nd edition, 2016.
3. Knaflic, Cole Nussbaumer. "*Storytelling with data: A data visualization guide for business professionals"*. John Wiley & Sons,1st edition, 2015.

	National Institute of Technology Meghalaya An Institute of National Importance	**CURRICULUM**

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-2020**
Department	**Computer Science and Engineering**	Semester	**VI**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS 326	**Multimedia**	**3**	**0**	**0**	**3**	**50**	**50**	**100**	**200**

Course Objectives		Course Outcomes		
	To understand the fundamentals concepts of multimedia systems such as multimedia information collection, processing and rendering.		CO1	**Able to describe the fundamental concepts, components of multimedia systems and multimedia tools.**
	To understand various technical aspects in terms of multimedia networking, signal processing, communication, file format, audio video, compression and its applications.		CO2	**Able to do the critical analysis and evaluation of internet applications, file format such as text, audio, video and compression techniques.**
	To design and develop multimedia based web design and networking applications.		CO3	**Able to design and develop the interactive multimedia systems for real time requirements.**
	To understand the real time requirement of multimedia systems, development multimedia software and performance analysis.		CO4	**Able to apply the principles to understand the protocols, multimedia information transmission, various storage techniques, standards.**
			CO5	**Able to design and develop the applications using networking protocols and also able to evaluate applications to achieve optimal performance.**

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	3	3	0	0	0	0	0	0	1	0	0	0	3	0	3
2	CO2	3	3	3	3	1	2	0	0	1	0	0	0	1	3	3
3	CO3	1	2	3	3	3	2	0	2	0	0	0	0	2	3	3
4	CO4	3	3	3	3	3	2	3	0	2	0	0	1	2	3	3
5	CO5	3	3	3	2	2	3	2	2	2	2	0	1	3	3	3

SYLLABUS

No.	Content	Hours	COs
I	**Introduction, Uses of multimedia, Analog & digital Presentation, Digitization , Nyquist Sampling Theorem Visual Display system, Overview of Multimedia Tools**	**04**	**CO1** **CO2**
II	**Introduction to Data compression, Huffman Coding, Shannon Fano Algorithm, Huffman Algorithms, Adaptive Huffman Coding, Dictionary based Compression, LZ78, LZW compression, compression ratio loss less & lossy compression**	**06**	**CO2** **CO3**
III	**Introduction to Text Using text in multimedia, Hypermedia and Hypertext, Introduction to image, Graphics, Image Data Types, Image File formats, Multiple monitors, bitmaps, Vector drawing, color principles, Raster Scan principles, color pallets, Dithering**	**06**	**CO2** **CO3**
IV	**Introduction to video, Broadcast television, HDTV, Analog display standards, digital display standards, Digital video, Video formats, Sound ,MIDI, Digital Audio, audio file formats, MIDI under windows environment Audio & Video Capture.**	**06**	**CO3** **CO4**
V	**Introduction to Animation, Animation file formats, Basic Software Tools, Multimedia Authoring tools.**	**04**	**CO2** **CO3** **CO4**
VI	**Introduction to multimedia networks, Quality of Multimedia Data Transmission, Multimedia over IP, RTP, RTSP, RTCP, Voice over IP,**	**04**	**CO4** **CO5**
VII	**Introduction to Image & Video Compression, J.P.EG, H.261, H.263, MPEG, Standards (MPEG1, MPEG 2, MPEG 4),GIF,TIFF**	**06**	**CO3** **CO4** **CO5**
	Total	**36**	

Essential Readings

1. Li & S.Drew "Fundamental of Multimedia "Pearson Prentice Hall, Volume 1st Edition, 2004.
2. Ranjan Paarekh "Fundamentals of Multimedia" TMH, 2nd Edition, 2017.
3. K.R. Rao, Zoran S. Bojkovic, Dragorad A. Milovanovic, "Multimedia Communication Systems Techniques, Standards and Networks", PHI, 1st Edition, 2002.

Supplementary Readings

1. Tay Vaughan "Multimedia, Making IT Work" TMH, 9th Edition, 2017.
2. Fred Halsal "Multimedia Communication" Pearson Education, 1st Edition, 2007.
3. K.R. Rao, Zoran S. Bojkovic, Bojan M. Bakmaz," Wireless Multimedia Communication Systems: Design, Analysis, and Implementation", CRC Press, 1st Edition, 2017.

	National Institute of Technology Meghalaya An Institute of National Importance	**CURRICULUM**

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2020-21**
Department	**Computer Science and Engineering**	Semester	**VI**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS 328	**System Software**	**3**	**0**	**0**	**3**	**50**	**50**	**100**	**200**

Course Objectives	To introduce the different system software for a general and simple computer architecture. To implement different assemblers for a general and simple computer architecture. To implement simple linker/loaders and macro for a general and simple computer architecture.	Course Outcomes	CO1	Student will be able to identify and distinguish among different system and application software.
			CO2	Student will be able to design different types of assemblers for a simple microprocessor.
			CO3	Student will be able to explain the requirements of linker/loader and also implement them for a simple system.
			CO4	Student will be able to explain the requirements of Macros and also implement them for a system.
			CO5	Student will be able to understand the working of different software like compiler, text editor and debuggers.

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**3**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**2**	**2**
2	CO2	**3**	**1**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**3**
3	CO3	**3**	**3**	**3**	**2**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**3**
4	CO4	**3**	**1**	**3**	**2**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**3**
5	CO5	**3**	**2**	**3**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**3**

SYLLABUS

No.	Content	Hours	COs
I	System and Application software, The Simplified Instruction Computer- SIC and SIC/XE,	**02**	**CO1**
II	Elements of Assembly Language Programming, Assembly Scheme, Machine-dependent Assembler Features, Pass Structure of Assembler, Design of Assembler -2 pass assemble for SIC, Data structure, Format of Database, Algorithm, Table processing: Searching and sorting, Machine-Independent Assembler Features, Multipass Assembler, A Single Pass Assembler for SIC.	**15**	**CO1, CO2**
III	Reallocation and Linking Concept, Design of Linker, Self Reallocation Programs, Loader, Absolute Loader, A Simple Bootstrap Loader, Reallocating Loader, Linking Loader, Design of a Loader.	**12**	**CO1, CO3**
IV	Macro Instructions, Features of Macro facility, Macro Instruction arguments, Generation of Unique labels, Conditional Macro Expansion, Keyword Macro parameters, Macro Instructions defining Macros, Recursive Macro Expansion, Macro Processor Algorithm and Data Structures.	**05**	**CO1, CO4**
V	Aspects of Compilation, Various phases of a compiler, Introduction to Language Processing Activity, Fundamental of Language Processing, Fundamental of Language Specification, Language Processor Development tool. Interactive Text Editor, Editing features, Type of Editor and user interface, Structure of a General Text Editor, Editor design and evaluation, Editors function in computing environments, Interactive Debugging System, Debugging Functions and Capabilities, Type of bugs, Debugging techniques, Debugging Tool, Command line Debugger, Types of analysis tool, Difficulties in Designing an Interactive Debugging System.	**05**	**CO1, CO5**
Total Hours		**39**	

Essential Readings:

1. Leland L. Beck , D. Manjula , " System Software -An Introduction to System Programming", 3rd ed., 1997, Addison Wesley.
2. M. Dhamdhere, " System Software and Operating System", 2nd ed. 1999, Tata McGraw-Hill.
3. Santanu chattopadhyay, "System software", 1st ed., 2007, PHI.

Supplementary Readings:

1. John J. Donovan, "System Programming", 1st ed., 2017, McGraw-Hill Education.
2. A.V. Aho, R. Sethi and J D. Ullman, "Compilers-Principles, Techniques and Tools", 2nd ed., 2006, Pearson Education.
3. J. Nithyashri, "System Software", 2nd ed., 2010, Tata McGraw Hill.

	National Institute of Technology Meghalaya An Institute of National Importance	**CURRICULUM**

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2019-20**
Department	**Computer Science and Engineering**	Semester	**VI**

Course Code	Course Name	Credit Structure				Marks Distribution			
		L	T	P	C	INT	MID	END	Total
CS 372	**Introduction to Machine Learning**	**2**	**0**	**0**	**2**	**50**	**50**	**100**	**200**

Course Objectives		Course Outcomes		
	To understand the different learning models and its usage in computer vision and data analytics.		CO1	Able to identify potential applications of machine learning in practice
	To understand the different classification algorithms and its application in image understanding and data clustering		CO2	Able to Describe the differences in approaches and applicability of regression, classification, and clustering
	To understand forecasting and different learning theory applied for prediction of desired conclusion in data analytics.		CO3	Able to use forecasting and prediction models using different learning theory
	Apply different unsupervised learning and reinforcement learning models in application areas like image forgery, image classification, data clustering and decision making process		CO4	Able to select the suitable machine learning models for decision making process
	To understand the dimension reduction process and handling of big data using machine learning models		CO5	Able to apply the dimension reduction process, feature selection process and use of machine learning models for big data

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**3**	**3**	**0**	**1**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**3**	**0**	**3**
2	CO2	**3**	**3**	**0**	**1**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**2**	**0**	**2**
3	CO3	**2**	**3**	**3**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**3**	**2**
4	CO4	**2**	**2**	**3**	**0**	**2**	**2**	**3**	**0**	**2**	**0**	**0**	**1**	**2**	**3**	**2**
5	CO5	**2**	**2**	**3**	**0**	**2**	**2**	**3**	**0**	**2**	**0**	**0**	**1**	**3**	**3**	**3**

SYLLABUS

No.	Content	Hours	COs
I	Introduction, Machine learning basics, Supervised Learning: Artificial Neural Network, classifying with k-Nearest Neighbour classifier, Support vector machine classifier, Decision Tree classifier.	**06**	**CO1**
II	Forecasting and Learning Theory: Predicting numeric values: regression, Linear Regression, Logistic regression, Tree-based regression. Bias/variance trade-off, Union and Chernoff / Hoeffding bounds, Vapnik–Chervonenkis (VC) dimension, Worst case (online) learning.	**08**	**CO2**
III	Unsupervised Learning: Grouping unlabeled items using k-means clustering, Association analysis with the Apriori algorithm, efficiently finding frequent item sets with FP-growth.	**05**	**CO1** **CO3**
IV	Reinforcement learning: Markov decision process (MDP), Bellman equations, Value iteration and policy iteration, Linear quadratic regulation, Linear Quadratic Gaussian, Q-learning, Value function approximation, Policy search, Reinforce, POMDPs.	**06**	**CO2** **CO3**
V	Dimensionality reduction: Feature extraction - Principal component analysis, Singular value decomposition. Feature selection – feature ranking and subset selection, filter, wrapper and embedded methods. Machine Learning for Big data: Big Data and Map Reduce.	**05**	**CO4** **CO5**
	Total Hours	**30**	

Essential Readings

1. Title: Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, 2nd Edition, 2019, O'Reilly Media, Inc.
2. Title: Introduction to Machine Learning, Author E. Alpaydin, Publisher: MIT Press, 2nd Edition, 2009.
3. Title: Machine Learning, Author: T. M. Mitchell, Publisher: McGraw-Hill, 1997 Edition.

Supplementary Readings

1. Title: Machine learning in action, Author: P. Harrington, Publisher: Manning Publications, 2012 Edition.
2. Title: Pattern recognition and Machine Learning, Author C. M. Bishop, Publisher: Springer, 2007 Edition.
3. Title: Machine Learning for Big Data: Hands-On for Developers and Technical Professionals, Author: J. Bell, Publisher: Wiley, 2014 Edition.

	National Institute of Technology Meghalaya An Institute of National Importance	CURRICULUM
Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation: **2019-20**
Department	**Computer Science and Engineering**	Semester: **VI**

Course Code	Course Name	Credit Structure				Marks Distribution		
		L	T	P	C	Continuous Evaluation	Lab Test/ Viva	Total
CS352	**Software Engineering Lab**	**0**	**1**	**2**	**2**	**70**	**30**	**100**

Course Objectives	Course Outcomes	
To introduce the Software Development life cycles Models	CO1	**Able to identify, formulate, and solve complex engineering problems**
To analyse the software requirements	CO2	**Able to recognize ethical and professional responsibilities in engineering situations**
To introduce various design methods for software Development	CO3	**Able to analyze, design, verify, validate, implement, apply, and maintain software systems**
To develop an ability and skill to test software systems	CO4	**Able to work in one or more significant application domain**

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**
2	CO2	**2**	**1**	**1**	**1**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**1**	**2**	**1**	**1**
3	CO3	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**
4	CO4	**1**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**1**	**1**	**1**	**1**

SYLLABUS

No.	Content	Hours	COs
I	**Software Development life cycles Models, Agile Process Models Software**	**06**	**CO1 CO2 CO3 CO4**
II	**Static program verification tool (SLAM) for verifying critical program behaviour, Data Modelling Concepts, Object Oriented Analysis, Flow-Oriented Modelling,**	**06**	
III	**Formal verification of concurrent systems using SPIN model checker.**	**06**	
IV	**DFD and UML Development for the requirements**	**06**	
V	**Design and coding using software development languages**	**06**	
VI	**Taxonomy of Quality Attributes, Perspectives of Quality, Quality System, Software Quality Assurance, Manual and automated testing tools.**	**06**	
	To be done necessarily as mini-project group-wise in groups of at least two/three students.		
Total Hours		**36**	

Essential Readings

1. Roger S Pressman: "Software Engineering – A Practitioner's Approach", 7th Edition, McGraw-Hill, 2009.
2. Rajib Mall, "Fundamentals of Software Engineering", 5th Edition, PHI, 2018.
3. Ian Sommerville: "Software Engineering". 9th Edition, Pearson Education, 2011.

Supplementary Readings

1. SLAM Reference- http://research.microsoft.com/en-us/projects/slam/
2. SPIN Model Checker Reference: http://spinroot.com/spin/whatispin.html
3. Paul Ammann, and Jeff Offutt, "Introduction to Software Testing", 1st Edition, Cambridge University Press, 2008.

	National Institute of Technology Meghalaya An Institute of National Importance	**CURRICULUM**

Programme	**Bachelor of Technology in Computer Science and Engineering**	Year of Regulation	**2020-21**
Department	**Computer Science and Engineering**	Semester	**VI**

Course Code	Course Name	Credit Structure				Marks Distribution		
		L	T	P	C	Continuous Evaluation	Lab Test / Viva	Total
CS 354	**Compiler Design Lab**	**0**	**1**	**2**	**2**	**70**	**30**	**100**

Course Objectives		Course Outcomes		
	The Objectives of this course is to explore the principles, algorithms, and data structures involved in the design and construction of compilers.		CO1	Specify and analyse the lexical, syntactic and semantic structures of any computer programming language.
			CO2	Separate the lexical, syntactic and semantic analysis into meaningful phases for a compiler to undertake language translation.
	To implement some phases of the front-end of a general compiler.		CO3	Write a scanner, parser, and semantic analyser for limited form of C like programming languages.
			CO4	Convert source code in simple language into machine code for a novel computer.
	To implement some phases of the backt-end of a general compiler.		CO5	Describe techniques for intermediate code and machine code optimisation.

No.	COs	Mapping with Program Outcomes (POs)												Mapping with PSOs		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	CO1	**3**	**2**	**3**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**2**
2	CO2	**3**	**3**	**3**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**1**	**1**	**3**
3	CO3	**2**	**3**	**3**	**1**	**3**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**1**	**3**
4	CO4	**2**	**1**	**1**	**2**	**2**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**1**	**3**
5	CO5	**2**	**1**	**2**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**3**

SYLLABUS

No.	Content	Hours	COs
I	1) Using Lex/Flex , write a program to append line number before each (i) lines(empty/non-empty). (ii) non-empty lines Input/output streams may be files. 2) Using Lex/Flex , write a program to count number of lines, words, visible characters, total characters. Input/output streams may be files.	**4**	**CO1, CO2, CO3**
II	3) Using Lex/Flex , write a program to identify some keywords, identifiers, integers and real numbers from a simple C program. Input/output streams may be files. 4) Lex program to copy a file by replacing multiple sequences of white spaces with a single white space. [blanks/tab => blank, more than one " \n" => " \n"]. 5) Also add removal of comments in above program.	**2**	**CO1, CO2, CO3**
III	6) Lex program to copy a C program by replacing each instance of the keyword *float* by *double*. 7) Write a Lex program that converts a file to "Pig Latin". Specifically, assume the file is sequence of English words (group of letters) separated by white space. Every time a word is encountered: 1. If the first letter is consonant, move it to the end of the word and then add ay. 2. If the first letter is a vowel, just add ay to the end of the word.	**2**	**CO1, CO2, CO3**
IV	8) Using Lex/Flex , write a program to encode and decode.	**2**	**CO1, CO2, CO3**
V	9) Using Lex/Flex , write a program to (i) identify the Roman numbers (ii) add 2 Roman numbers.	**2**	**CO1, CO2, CO3**
VI	10) Create a recursive predictive parser for a grammar(as given in lab class).	**2**	**CO1, CO2, CO3**
VII	11) Create a non-recursive predictive parser(LL parser) for a grammar(as given in lab class).	**2**	**CO1, CO2, CO3**
VIII	12) Using Flex and Bison tools, create a calculator program that support addition,subtraction, multiplication, division, power operations on numbers and variables.	**4**	**CO1, CO2, CO3**
IX	13) Using Flex and Bison tools, create a translator to convert a simple program written in arbitrary language to a program in C language.	**2**	**CO1,CO4**
X	14) Using Flex and Bison tools, create a program to convert a simple assignment expression into intermediate code. Ex:- input: z = -(a+b-c) output: t1 = a + b t2 = t1 – c	**2**	**CO1,CO5**

	t3 = - t2 z = t3		
Total Hours		**24**	

Essential Readings:

1. A.V. Aho, M. S. Lam, R. Sethi and J. D. Ullman, "Compilers-Principles, Techniques and Tools", 2nd ed., 2006, Pearson Education.
2. K. Muneeswaran, "Compiler Design", 1st ed., 2013, Oxford Publication.
3. P.H. Dave, H.B. Dave, "Compilers: Principles and Practice", 1st ed. 2012, Pearson Education.

Supplementary Readings:

1. Allen I. Holub, "Compiler Design in C", 1st ed.(Indian print), 2012, PHI.
2. John Levine, "Flex & Bison ", 1st ed., 2009, O'reilly.
3. Torben Ægidius Mogensen, "Basics of Compiler Design", 1st ed., 2007, DIKU, University of Copenhagen