VIT®
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

School of Computer Science and Engineering

CURRICULUM AND SYLLABI

(2024-2025)

M. Tech. Computer Science and Engineering (Artificial Intelligence and Machine Learning)

VIT®
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

VISION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

Transforming life through excellence in education and research.

MISSION STATEMENT OF VELLORE INSTITUTE OF TECHNOLOGY

- **World class Education**: Excellence in education, grounded in ethics and critical thinking, for improvement of life.
- **Cutting edge Research**: An innovation ecosystem to extend knowledge and solve critical problems.
- **Impactful People**: Happy, accountable, caring and effective workforce and students.
- **Rewarding Co-creations**: Active collaboration with national & international industries & universities for productivity and economic development.
- **Service to Society**: Service to the region and world through knowledge and compassion.

VISION STATEMENT OF THE SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

- To be a world-renowned centre of education, research and service in computing and allied domains.

MISSION STATEMENT OF THE SCHOOL OF COMPUTER SCIENCE AND ENGINEERING

- To offer computing education programs with the goal that the students become technically competent and develop lifelong learning skill.
- To undertake path-breaking research that creates new computing technologies and solutions for industry and society at large.
- To foster vibrant outreach programs for industry, research organizations, academia and society.

VIT®
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

M. Tech. Computer Science and Engineering (Artificial Intelligence and Machine Learning)

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. Graduates will be engineering professionals who will engage in technology development and deployment with social awareness and responsibility.
2. Graduates will function as successful practicing engineer / researcher / teacher / entrepreneur in the chosen domain of study.
3. Graduates will have holistic approach addressing technological, societal, economic and sustainability dimension of problems and contribute to economic growth of the country.

VIT
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

M. Tech. Computer Science and Engineering (Artificial Intelligence and Machine Learning)

PROGRAMME OUTCOMES (POs)

- PO_1 Having an ability to apply mathematics and science in engineering applications.
- PO_3 Having an ability to design a component or a product applying all the relevant standards and with realistic constraints including public health, safety, culture,society and environment.
- PO_4 Having an ability to design and conduct experiments, as well as to analyze and interpret data, and synthesis of information.
- PO_5 Having an ability to use techniques, skills, resources and modern engineering tools necessary for engineering and IT tools necessary for engineering practices.
- PO_6 Having problem solving ability-solving social issues (societal, health, safety, legacy and cultural) and engineering problems.
- PO_7 Having adaptive thinking and adaptability in relation to environment and context and sustainable development.
- PO_8 Having a clear understanding of professional and ethical responsibility.
- PO_11 Having a good cognitive load management skills related to project management and finance.

VIT
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

M. Tech. Computer Science and Engineering (Artificial Intelligence and Machine Learning)

ADDITONAL PROGRAMME OUTCOMES (APOs)

- APO_2 Having Sense-Making Skills of creating unique insights in what is being seen or observed (Higher level thinking skills which cannot be codified).
- APO_3 Having design thinking capability.
- APO_4 Having computational thinking (Ability to translate vast data in to abstract concepts and to understand database reasoning).
- APO_7 Having critical thinking and innovative skills.
- APO_8 Having a good digital footprint.

VIT®
Vellore Institute of Technology
(Deemed to be University under section 3 of UGC Act, 1956)

M. Tech. Computer Science and Engineering (Artificial Intelligence and Machine Learning)

PROGRAMME SPECIFIC OUTCOMES (PSOs)

1. The ability to formulate mathematical models and problem-solving skills through programming techniques for addressing real-life problems using appropriate knowledge representation, problem-solving and learning methods.
2. Become familiar with the insights of Artificial Intelligence and Machine Learning towards problem solving, inference, perception, knowledge representation and learning.
3. Ability to bring out the capabilities for research and development in contemporary issues and to exhibit the outcomes as technical report.

Category Credit Detail			
Sl.No.	**Description**	**Credits**	**Maximum Credit**
1	DC - Discipline Core	24	24
2	SPE - Specialization Elective	12	12
3	PI - Projects and Internship	26	26
4	OE - Open Elective	3	3
5	SE - Skill Enhancement	5	5
Total Credits		70	

Discipline Core									
sl.no	**Course Code**	**Course Title**	**Course Type**	**Version**	**L**	**T**	**P**	**J**	**Credits**
1	MCSE501L	Data Structures and Algorithms	Theory Only	1.0	3	0	0	0	3.0
2	MCSE501P	Data Structures and Algorithms Lab	Lab Only	1.0	0	0	2	0	1.0
3	MCSE502L	Design and Analysis of Algorithms	Theory Only	1.0	3	0	0	0	3.0
4	MCSE502P	Design and Analysis of Algorithms Lab	Lab Only	1.0	0	0	2	0	1.0
5	MCSE503L	Computer Architecture and Organisation	Theory Only	1.0	3	0	0	0	3.0
6	MCSE503P	Computer Architecture and Organisation Lab	Lab Only	1.0	0	0	2	0	1.0
7	MCSE504L	Operating Systems	Theory Only	1.0	3	0	0	0	3.0
8	MCSE504P	Operating Systems Lab	Lab Only	1.0	0	0	2	0	1.0
9	MCSE505L	Computer Networks	Theory Only	1.0	3	0	0	0	3.0
10	MCSE505P	Computer Networks Lab	Lab Only	1.0	0	0	2	0	1.0
11	MCSE506L	Database Systems	Theory Only	1.0	3	0	0	0	3.0
12	MCSE506P	Database Systems Lab	Lab Only	1.0	0	0	2	0	1.0

Specialization Elective									
sl.no	**Course Code**	**Course Title**	**Course Type**	**Version**	**L**	**T**	**P**	**J**	**Credits**
1	MCSE601L	Artificial Intelligence	Theory Only	1.0	3	0	0	0	3.0
2	MCSE602L	Machine Learning	Theory Only	1.0	2	0	0	0	2.0
3	MCSE602P	Machine Learning Lab	Lab Only	1.0	0	0	2	0	1.0
4	MCSE603L	Deep Learning	Theory Only	1.0	2	0	0	0	2.0
5	MCSE603P	Deep Learning Lab	Lab Only	1.0	0	0	2	0	1.0
6	MCSE604L	Speech and Natural Language Processing	Theory Only	1.0	3	0	0	0	3.0
7	MCSE605L	Machine Vision	Theory Only	1.0	3	0	0	0	3.0
8	MCSE606L	Cognitive Robotics	Theory Only	1.0	3	0	0	0	3.0
9	MCSE607L	Game Programming	Theory Only	1.0	2	0	0	0	2.0
10	MCSE607P	Game Programming Lab	Lab Only	1.0	0	0	2	0	1.0

Projects and Internship									
sl.no	Course Code	Course Title	Course Type	Version	L	T	P	J	Credits
1	MCSE698J	Internship I/ Dissertation I	Project	1.0	0	0	0	0	10.0
2	MCSE699J	Internship II / Dissertation II	Project	1.0	0	0	0	0	12.0
3	MSET695J	Project Work	Project	1.0	0	0	0	0	4.0

Open Elective									
sl.no	Course Code	Course Title	Course Type	Version	L	T	P	J	Credits
1	MCSE627L	Programming for Data Science	Theory Only	1.0	2	0	0	0	2.0
2	MCSE627P	Visual Analytics Lab	Lab Only	1.0	0	0	2	0	1.0
3	MCSE628L	Artificial Intelligence with Machine Learning	Theory Only	1.0	2	0	0	0	2.0
4	MCSE628P	Artificial Intelligence with Machine Learning Lab	Lab Only	1.0	0	0	2	0	1.0
5	MCSE631L	Data Engineering	Theory Only	1.0	2	0	0	0	2.0
6	MCSE632L	Application Architecture with Deployment	Theory Only	1.0	2	0	0	0	2.0
7	MFRE501L	Francais Fonctionnel	Theory Only	1.0	3	0	0	0	3.0
8	MGER501L	Deutsch fuer Anfaenger	Theory Only	1.0	3	0	0	0	3.0
9	MSTS601L	Advanced Competitive Coding	Soft Skill	1.0	3	0	0	0	3.0

Skill Enhancement									
sl.no	Course Code	Course Title	Course Type	Version	L	T	P	J	Credits
1	MENG501P	Technical Report Writing	Lab Only	1.0	0	0	4	0	2.0
2	MSTS501P	Qualitative Skills Practice	Soft Skill	1.0	0	0	3	0	1.5
3	MSTS502P	Quantitative Skills Practice	Soft Skill	1.0	0	0	3	0	1.5

Course Code	Course Title	L	T	P	C
MCSE501L	Data Structures and Algorithms	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To familiarize the concepts of data structures and algorithms focusing on space and time complexity.
2. To provide a deeper insight into the basic and advanced data structures.
3. To develop the knowledge for the application of advanced trees and graphs in real-world scenarios.

Course Outcomes

1. Understand and analyze the space and time complexity of the algorithms.
2. Identification of suitable data structure for a given problem.
3. Implementation of graph algorithms in various real-life applications.
4. Implementation of heaps and trees for querying and searching.
5. Use of basic data structures in advanced data structure operations.
6. Use of searching and sorting in various real-life applications.

Module:1	**Growth of Functions**	**3 hours**
Overview and importance of algorithms and data structures- Algorithm specification, Recursion, Performance analysis, Asymptotic Notation - The Big-O, Omega and Theta notation, Programming Style, Refinement of Coding - Time-Space Trade Off, Testing, Data Abstraction.		
Module:2	**Elementary Data Structures**	**6 hours**
Array, Stack, Queue, Linked-list and its types, Various Representations, Operations & Applications of Linear Data Structures		
Module:3	**Sorting and Searching**	**7 hours**
Insertion sort, merge sort, sorting in linear Time-Lower bounds for sorting, Radix sort, Bitonic sort, Cocktail sort, Medians and Order Statistics-Minimum and maximum, Selection in expected linear time, Selection in worst-case linear time, linear search, Interpolation search, Exponential search.		
Module:4	**Trees**	**6 hours**
Binary trees- Properties of Binary trees, B-tree, B-Tree definition- Operations on B-Tree: Searching a B-tree, Creating, Splitting, Inserting and Deleting, B+-tree.		
Module:5	**Advanced Trees**	**8 hours**
Threaded binary trees, Leftist trees, Tournament trees, 2-3 tree, Splay tree, Red-black trees, Range trees.		
Module:6	**Graphs**	**7 hours**
Representation of graphs, Topological sorting, Shortest path algorithms- Dijkstra's algorithm, Floyd-Warshall algorithm, Minimum spanning trees - Reverse delete algorithm, Boruvka's algorithm.		
Module:7	**Heap and Hashing**	**6 hours**
Heaps as priority queues, Binary heaps, binomial and Fibonacci heaps, Heaps in Huffman coding, Extendible hashing.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)

1. Cormen, Thomas H., Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. Introduction to algorithms. MIT press, 2022.

Reference Books

1. Skiena, Steven S. "The Algorithm Design Manual (Texts in Computer Science)." 3rd

	edition, 2020, Springer.
2.	Brass, Peter. Advanced data structures. Vol. 193. Cambridge: Cambridge University Press, 2008.

Mode of Evaluation: CAT / Written Assignment / Quiz / FAT			
Recommended by Board of Studies	26-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCSE501P	Data Structures and Algorithms Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To familiarize the concepts of data structures and algorithm focusing on space and time complexity.
2. To provide a deeper insight on the basic and advanced data structures.
3. To develop the knowledge for application of the advanced trees and graphs in real world scenarios.

Course Outcome

1. Understand and analyze the space and time complexity of the algorithms.
2. Identification of suitable data structure for a given problem.
3. Implementation of graph algorithms in various real-life applications.
4. Implementation of heaps and trees for querying and searching.
5. Use of basic data structures in advanced data structure operations.
6. Use of searching and sorting in various real-life applications.

Indicative Experiments

1.	Analyzing the complexity of iterative and recursive algorithms
2.	Implement Linear data structures (Stacks, Queues, Linked Lists)
3.	Linear time sorting techniques
4.	Interpolation search & Exponential search
5.	Binary tree & Tree traversals
6.	B-trees & B+ trees
7.	Advanced Trees: 2-3 tree, splay tree, red black tree etc.
8.	Advanced Trees: Threaded Binary trees, tournament trees
9.	Graph traversals (BFS, DFS, Topological sorting)
10.	Determining the Shortest path between pair of nodes in the given graph
11.	Minimum Spanning trees- reverse delete & Boruvka's algorithm
12.	Heaps & Hashing
	Total Laboratory Hours | **30 hours**

Text Book(s)

1.	Cormen, Thomas H., Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. Introduction to algorithms. MIT press, 2022.

Reference Books

1.	Skiena, Steven S. "The Algorithm Design Manual (Texts in Computer Science)." 3rd edition, 2020, Springer.
2.	Brass, Peter. Advanced data structures. Vol. 193. Cambridge: Cambridge University Press, 2008.

Mode of Evaluation: CAT / Mid-Term Lab/ FAT

Recommended by Board of Studies	26-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCSE502L	Design and Analysis of Algorithms	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To provide a mathematical framework for the design and analysis of algorithms.
2. To disseminate knowledge on how to create strategies for dealing with real-world problems.
3. To develop efficient algorithms for use in a variety of engineering design settings.

Course Outcomes

On completion of this course, student should be able to:

1. Apply knowledge of computing and mathematics to algorithm design.
2. Apply various algorithm paradigms to solve scientific and real-life problems.
3. Demonstrate the string matching and network flow algorithms relating to real-life problems.
4. Understand and apply geometric algorithms.
5. Apply linear optimization techniques to various real-world linear optimization problems.
6. Explain the hardness of real-world problems with respect to algorithmic design.

Module:1	**Greedy, Divide and Conquer Techniques Introduction**	**6 hours**
Overview and Importance of Algorithms - Stages of algorithm development: Describing the problem, Identifying a suitable technique, Design of an algorithm, Illustration of Design Stages - Greedy techniques: Graph Coloring Problem, Job Sequencing Problem with Deadlines- Divide and Conquer: Karatsuba's fast multiplication method, the Strassen algorithm for matrix multiplication		
Module:2	**Dynamic Programming, Backtracking and Branch & Bound Techniques**	**9 hours**
Dynamic programming: Matrix Chain Multiplication, Longest Common Subsequence. Backtracking: N-Queens problem, Subset Sum, Graph Coloring- Branch & Bound: A-Star, LIFO-BB and FIFO BB methods.		
Module:3	**Amortized analysis and String Matching Algorithms**	**6 hours**
Stack operation and Incrementing Binary counter -The aggregate method, the accounting method, the potential method, and Dynamic tables. Naïve String matching Algorithms, KMP algorithm, Rabin-Karp Algorithm, String matching with Finite Automata.		
Module:4	**Network Flow Algorithms**	**6 hours**
Flow Networks, Maximum Flows: Ford-Fulkerson, Edmond-Karp, Push relabel Algorithm, The relabel-to-front algorithm, Minimum Cost flows – Cycle Cancelling Algorithm.		
Module:5	**Computational Geometry**	**5 hours**
Line Segments – properties, intersection; Convex Hull finding algorithms- Graham's Scan, Jarvis's March Algorithm.		
Module:6	**Linear Optimization and Randomized algorithms**	**5 hours**
Linear Programming problem - Simplex Method-Big M Method, LP Duality- The hiring problem, Finding the global Minimum Cut.		
Module:7	**NP Completeness and Approximation Algorithms**	**6 hours**
The Class P - The Class NP - Reducibility and NP-completeness - Circuit Satisfiability problem-SAT 3CNF, Independent Set, Clique, Approximation Algorithm: Vertex Cover, Set Cover and Travelling salesman.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)		
1.	Cormen, Thomas H., Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. Introduction to algorithms. MIT press, 2022.	
Reference Books		
1.	Rajeev Motwani, Prabhakar Raghavan; “Randomized Algorithms, Cambridge University Press, 1995 (Online Print — 2013).	
2.	Ravindra K. Ahuja, Thomas L. Magnanti, and James B. Orlin, Network Flows: Theory, Algorithms, and Applications, 1st Edition, Pearson Education, 2014.	
3.	Jon Kleinberg and EvaTardos, Algorithm Design, Pearson Education, 1“Edition, 2014.	
Mode of Evaluation: CAT / Written Assignment / Quiz / FAT		
Recommended by Board of Studies	26-07-2022	
Approved by Academic Council	No. 67	Date 08-08-2022

Course Code	Course Title	L	T	P	C
MCSE502P	Design and Analysis of Algorithms Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To provide a mathematical framework for the design and analysis of algorithms.
2. To disseminate knowledge on how to create strategies for dealing with real-world problems.
3. To develop efficient algorithms for use in a variety of engineering design settings.

Course Outcome

On completion of this course, student should be able to:

1. Apply knowledge of computing and mathematics to algorithm design.
2. Apply various algorithm paradigms to solve scientific and real-life problems.
3. Demonstrate the string matching and network flow algorithms relating to real-life problems.
4. Understand and apply geometric algorithms.
5. Apply linear optimization techniques to various real-world linear optimization problems.
6. Explain the hardness of real-world problems with respect to algorithmic design.

Indicative Experiments

1.	Greedy Strategy : Graph Coloring Problem, Job Sequencing Problem with Deadlines
2.	Divide and Conquer : Karatsuba's fast multiplication method, the Strassen algorithm for matrix multiplication
3.	Dynamic Programming: Matrix Chain Multiplication, Longest Common Subsequence, 0-1 Knapsack
4.	Backtracking: N-queens, Subset sum
5.	Branch and Bound: Job selection
6.	String Matching Algorithms: Rabin Karp Algorithm, KMP Algorithm
7.	Network Flows : Ford -Fulkerson and Edmond – Karp, Cycle cancelling algorithm
8.	Minimum Cost flows – Cycle Cancelling Algorithm
9.	Linear programming: Simplex method
10.	Randomized Algorithms: Las Vegas and Monte carlo
11.	Polynomial time algorithm for verification of NPC problems
12.	Approximation Algorithm: Vertex cover ,Set cover and TSP
	Total Laboratory Hours **30 hours**

Text Book(s)

1.	Cormen, Thomas H., Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. Introduction to algorithms. MIT press, 2022.

Reference Books

1.	Rajeev Motwani, Prabhakar Raghavan; Randomized Algorithms, Cambridge University Press, 1995 (Online Print — 2013).
2	Ravindra K. Ahuja, Thomas L. Magnanti, and James B. Orlin, Network Flows: Theory, Algorithms, and Applications, 1st Edition, Pearson Education, 2014.
3	Jon Kleinberg and EvaTardos, Algorithm Design, Pearson Education, 1“Edition, 2014.

Mode of Evaluation: CAT / Mid-Term Lab/ FAT

Recommended by Board of Studies	26-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCSE503L	Computer Architecture and Organisation	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To provide knowledge on the basics of computer architectures and organization that lays the foundation to study high-performance architectures
2. To design and develop parallel programs using parallel computing platforms such as OpenMP, CUDA
3. To evaluate the performance using profiling tools and optimize parallel codes using various optimization techniques

Course Outcomes

1. Outline the developments in the evolution of computer architectures and parallel programming paradigms
2. Comprehend the various programming languages and libraries for parallel computing platforms
3. Use of profiling tools to analyze the performance of applications by interpreting the given data
4. Evaluate efficiency trade-offs among alternative parallel computing architectures for an efficient parallel application design
5. Develop parallel programs using OpenMP and CUDA and analyze performance parameters such as speed-up, and efficiency for parallel programs against serial programs

Module:1	Computer Evolution And Performance	5 hours

Defining Computer Architecture and Organization, Overview of Computer Components, Von Neumann architecture, Harvard Architecture CISC & RISC, Flynn's Classification of Computers, Moore's Law, Multi-threading, Comparisons of Single Core, Multi Processors, and Multi-Core architectures, Metrics for Performance Measurement

Module:2	Memory Hierarchy	8 hours

Key Characteristics of Memory systems, Memory Hierarchy, Cache Design policies, Cache Performance, Cache Coherence, Snoopy Protocols, Cache coherence protocols, MSI, MESI, MOESI

Module:3	Parallel Computers	8 hours

Instruction Level Parallelism(ILP), Compiler Techniques for ILP & Branch Prediction, Thread Level Parallelism (TLP), Threading Concepts, Shared Memory, Message Passing, Vectorization

Module:4	Multithreaded Programming using OpenMP	6 hours

Introduction to OpenMP, Parallel constructs, Runtime Library routines, Work-sharing constructs, Scheduling clauses, Data environment clauses, atomic, master Nowait Clause, Barrier Construct

Module:5	Programming for GPU	6 hours

Introduction to GPU Computing, CUDA Concepts, CUDA Programming Model, Program Structure of CUDA & Execution, Methods for operations on Device Memory, Thread Organization, Examples

Module:6	Performance Analyzers	6 hours

Performance Evaluation, performance bottlenecks, Profiling categories; Profiling tools: Trace analyzer and collector (ITAC), VTune Amplifier XE, Energy Efficient Performance, Integrated Performance Primitives (IPP)

Module:7	Energy Efficient Architectures	5 hours

Overview of power issues, CMOS Device-level Power dissipation basics, Sources of energy Consumption, Strategies to save power or Energy, Low power designs, Power management

techniques			
Module:8	**Contemporary Issues**		1 hours
	Total Lecture hours:		45 hours
Text Book(s)			
1.	William Stallings, Computer Organization and Architecture: Designing for Performance, Pearson, 2022, 11th Edition, Pearson		
2	Gerassimos Barlas, Multicore and GPU Programming: An Integrated Approach, 2022, 2nd edition, Morgan Kaufmann		
Reference Books			
1.	J.L. Hennessy and D.A. Patterson. Computer Architecture: A Quantitative Approach. 5th Edition, 2012, Morgan Kauffmann Publishers.		
2.	Shameem Akhter, Jason Roberts, Multi-core Programming: Increasing Performance Through Software Multi-threading, 2010, Intel Press, BPB Publications		
Mode of Evaluation: CAT / Written Assignment / Quiz / FAT			
Recommended by Board of Studies	26-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCSE503P	Computer Architecture and Organisation Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To provide knowledge on basics of computer architectures and organization that lays foundation to study high performance architectures
2. To design and develop parallel programs using parallel computing platforms such as OpenMP, CUDA
3. To evaluate the performance using profiling tools and optimize parallel codes using various optimization techniques

Course Outcome

1. Outline the developments in the evolution of computer architectures and parallel programming paradigms
2. Comprehend the various programming languages and libraries for parallel computing platforms
3. Use of profiling tools to analyze the performance of applications by interpreting the given data
4. Evaluate efficiency trade-offs among alternative parallel computing architectures for an efficient parallel Application design.
5. Develop parallel programs using OpenMP and CUDA and analyze performance parameters such as speed-up, efficiency for parallel programs against serial programs

Indicative Experiments

1.	Set-up an environment for OpenMP Programming: Activities: create a Project using Visual Studio, Writing Sample OpenMp Program, Setting up properties, compile & Execute OpenMP program, OpenMP manual study, Creation of Login credential on Intel for Intel Parallel Studio
2.	OpenMP program using following construct and describe scenario for the need of construct Use of Parallel Construct, Determine the Number of processors in a parallel Region, Find the thread ID of each processor
3.	Computation of Execution Time Using OpenMP clock, Using windows clock
4.	OpenMP Program using various Environment Routines to access the processor run-time information and write interesting observations by comparing various routines
5.	OpenMP program using following Worksharing Constructs and describe scenario for the need of construct loop construct, sections construct, single construct
6.	OpenMP program using following schedule clauses and describe scenario for the need of clause Static, Dynamic, Guided
7.	Develop parallel programs for given serial programs and profile the program using Vtune Analysis tool Matrix-Matrix multiplication, Matrix-Vector multiplication
8.	Develop parallel programs for given serial programs and profile the program using Vtune Analysis tool Quicksort, Minimum Spanning Tree
9.	CUDA-platform setup on NVIDIA / Google Colab
10.	Write a CUDA C/C++ program that add two array of elements and store the result in third array
11.	Write a CUDA C/C++ program that Reverses Single Block in an Array; CUDA C/C++

12.	Write a CUDA C program for Matrix addition and Multiplication using Shared memory			
			Total Laboratory Hours	**30 hours**
Text Book(s)				
1.	Gerassimos Barlas, Multicore and GPU Programming: An Integrated Approach, 2022, 2nd edition, Morgan Kaufmann			
Reference Books				
1.	Shameem Akhter, Jason Roberts, Multi-core Programming: Increasing Performance Through Software Multi-threading, 2010, Intel Press, BPB Publications			
Mode of Evaluation: CAT / Mid-Term Lab/ FAT				
Recommended by Board of Studies		26-07-2022		
Approved by Academic Council		No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCSE504L	Operating Systems	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To focus the core functionalities required to develop and manage operating systems.
2. To encompass process management, synchronization strategies, memory management, file systems, device management, and virtualization.
3. To introduce the concepts and features of real-time operating systems as well as virtualization.

Course Outcomes

1. Understand the fundamental operating system abstractions, including processes, threads, semaphores, and file systems.
2. Implement scheduling, devising and addressing synchronization issues.
3. Gain an understanding of memory management tasks.
4. Develop real-time working prototypes of different small-scale and medium-scale embedded systems.
5. Comprehend the basics of virtualization and differentiate types of virtualization.

Module:1	Introduction to Operating Systems	4 hours

Computer Organization and Architecture - OS definition – OS history – OS Operations – OS design issues - Operating systems structures - Library files - Systems calls – Interrupts - Kernel approaches – Building and booting an OS.

Module:2	Process and Scheduling	6 hours

Process states – State transitions with suspend and resume - Process control block - Context-switching - Processes operations - Process scheduling - CPU scheduling: Non-preemptive, preemptive - Multi-queue scheduling - Multi-level feedback queue scheduling.

Module:3	Synchronization	9 hours

IPC: Shred memory, message passing - Race condition – Critical section problem - Peterson's solution – Bakery Algorithm - Mutex locks - Semaphores – Classical synchronization problems – Monitors - Thread synchronization – Multi-threading Models, Deadlocks – Resource allocation graphs – Deadlock: prevention, avoidance, detection and recovery.

Module:4	Memory Management	5 hours

Address binding – Fragmentation - Pinning Memory – Paging – Structure of the page table – Swapping - Segmentation - Demand Paging – Copy-on-write - Replacement – Thrashing – Working set – Memory compression – Allocating kernel memory.

Module:5	Managing Devices, Files, Security and Protection	9 hours

I/O Management – DMA - Delayed write - Disk scheduling algorithms: Seek-time and rotational latency based - File control block – Inode – Access method – Directory structure - Directory implementation – File allocation methods - Free space management – Program and network threats – Cryptography as a security tool – Domains of protection – Access matrix – Capability based systems

Module:6	Real-time Operating Systems	5 hours

RTOS Internals - Real-Time Scheduling - Task Specifications - Performance Metrics of RTOS - Schedulability Analysis – RTOS Programming Tools.

Module:7	Virtualization	5 hours

Need for virtualization - Virtual machines and architectures – Hypervisors - Virtualization Technologies: Para Virtualization, Full Virtualization - Virtualization types: Server virtualization, Application virtualization, Storage virtualization.

Module:8	Contemporary Issues	2 hours

	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Abraham Silberschatz, Peter B. Galvin, Greg Gagne, “Operating System Concepts”, 2018, 10th Edition, Wiley, United States.
Reference Books	
1.	Arpaci-Dusseau, R. H., & Arpaci-Dusseau, A. C, “Operating Systems: Three easy pieces, 2018, 1st Edition, Boston: Arpaci-Dusseau Books LLC.
2.	Kamal, R, Embedded Systems: Architecture, Programming and Design, 2011, 1st Edition, Tata McGraw-Hill Education.
3.	Portnoy, M, “Virtualization Essentials”, 2012, 2nd Edition, John Wiley & Sons, New Jersey, USA.

Mode of Evaluation: CAT / Written Assignment / Quiz / FAT			
Recommended by Board of Studies	26-07-2022		
Approved by Academic Council	No.67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCSE504P	Operating Systems Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To encompass process management, synchronization strategies, memory management, file systems, device management, and virtualization.
2. To introduce the concepts and features of real-time operating systems as well as virtualization.

Course Outcome

1. Implement scheduling, devising and addressing synchronization issues.
2. Gain an understanding of memory management tasks.
3. Develop real-time working prototypes of different small-scale and medium-scale embedded systems.
4. Comprehend the basics of virtualization and differentiate types of virtualization.

Indicative Experiments

1.	Investigate the fundamental Unix/Linux commands.
2.	Obtaining the OS system data file and its associated information.
3.	Shell Programming.
4.	Create utility programs that use I/O system calls to simulate operations such as ls, cp, grep, and others.
5.	Create child, Orphan and Zombie processes using suitable system calls such as fork(), exec(), wait(), kill(), sleep() and exit() system calls.
6.	Create a program that mimics the CPU Scheduling algorithms including multi-level queue scheduling algorithm. Ex: Assume that all processes in the system are divided into two categories: system processes and user processes. System processes are to be given higher priority than user processes. Use FCFS scheduling for the processes in each queue.
7.	Implement the deadlock-free solution to Dining Philosophers problem using Semaphore.
8.	Simulation of Bankers algorithm to check whether the given system is in safe state or not. Also check whether addition resource requested can be granted immediately.
9.	Parallel Thread management using Pthreads library. Implement a data parallelism using multi-threading. Ex: An application should have a thread created with synchronization and thread termination. Every thread in the sub-program must return the value and must be synchronized with the main function. Final consolidation should be done by the main (main function).
10.	Dynamic memory allocation algorithms – First-fit, Best-fit, Worst-fit algorithms.
11.	Page Replacement Algorithms FIFO, LRU and Optimal
12.	Implement a file locking mechanism.
13.	RTOS Based Parameter Monitoring and Controlling System – Monitoring: Collecting data from sensors and interface display devices/actuators using a microcontroller. Controlling: Provide an alert when the received data reaches a certain threshold value.
14.	Virtualization Setup: Type-1, Type-2 Hypervisor (Detailed Study Report).
	Total Laboratory Hours | **30 hours**

Text Book(s)

1.	Vijay Mukhi, “The C Odyssey: UNIX: v. 3”, 2004, 3rd Edition, BPB Publications, New Delhi, India.

Reference Books			
1.	Stevens, W. R., & Rago, S. A. (2013). Advanced Programming in the UNIX Environment: Advanc Progra UNIX Envir_p3. Addison-Wesley.		
2.	Love, Robert, “Linux System Programming: talking directly to the kernel and C library”, 2013, 2nd Edition, O’Reilly Media, Inc, United States.		
Mode of Evaluation: CAT / Mid-Term Lab/ FAT			
Recommended by Board of Studies	26-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCSE505L	Computer Networks	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To learn various network models, layers and their protocols.
2. To gain a fundamental understanding of routing algorithms.
3. To comprehend the basics of wireless as well as mobile networks and their characteristics.

Course Outcomes

1. Explore the basics of Computer Networks and various performance metrics.
2. Interpret the application layer services and their protocols.
3. Evaluate the requirements for reliable services and implications of congestion at the transport layer services.
4. Analyse various functionalities required in the control and data plane at network layer services.
5. Infer the characteristics of wireless as well as mobile networks and their security standards.

Module:1	Computer Networks and the Internet	7 hours

Internet: A Nuts-and-Bolts Description - Network Protocols - The Network Edge: Access Networks and Physical Media - The Network Core: Packet Switching, Circuit Switching - Network of Networks - Delay, Loss and Throughput in Packet-Switched Networks - Protocol Layers and Their Service Models

Module:2	Application Layer	5 hours

Principles of Network Applications: Architectures, Processes and Transport Services - The Web and HTTP - Electronic Mail in the Internet - DNS—The Internet's Directory Service - Peer-to-Peer File Distribution - Socket Programming: Creating Network Applications

Module:3	Transport Layer	7 hours

Relationship Between Transport and Network Layers - Overview of the Transport Layer in the Internet - Multiplexing and Demultiplexing - Connectionless Transport: UDP - Reliable Data Transfer: Go-Back-N (GBN) and Selective Repeat (SR) - Connection-Oriented Transport: TCP, Flow Control and Congestion Control

Module:4	Network Layer: Data Plane	5 hours

Network Layer – Router - The Internet Protocol (IP): IPv4, Addressing and IPv6 - Generalized Forwarding and SDN

Module:5	Network Layer: Control Plane	5 hours

Control Plane: Per-router control and logically centralized control - Routing Algorithms - Link-State (LS) Routing Algorithm, Distance-Vector (DV) Routing Algorithm, Intra-AS Routing in the Internet: OSPF and Routing Among the ISPs: BGP - SDN Control Plane

Module:6	Link Layer and LANs	8 hours

Overview of Link Layer Services - Error-Detection and -Correction Techniques: Parity Checks, Checksum and CRC - Multiple Access Links and Protocols: Channel Partitioning Protocols and Random-Access Protocols - Switched Local Area Networks: Link-Layer Addressing and ARP - Virtual Local Area Networks

Module:7	Wireless and Mobile Networks-Security	6 hours

Elements of a wireless network - Wireless Links and Network Characteristics - WiFi: 802.11 Wireless LANs - Mobility Management: Principles - Wireless and Mobility: Impact on Higher-Layer Protocol- Security in Computer Network- Message Integrity and Digital Signatures - Network-Layer Security: IPsec and Virtual Private Networks

Module:8	Contemporary Issues	2 hours

	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	James F. Kurose, Keith W. Ross, “Computer Networking: A Top-Down Approach”, 2022, 8th Edition(Paperback), Pearson, United Kingdom.
Reference Books	
1.	Larry Peterson and Bruce Davie, “Computer Networks: A Systems Approach”, 2019, 6th Edition, Morgan Kaufmann, United States of America.
2.	Andrew S. Tanenbaum, “Computer Networks”, 2013, 6th Edition, Pearson, Singapore.
Mode of Evaluation: CAT / Written Assignment / Quiz / FAT	

Recommended by Board of Studies	26-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCSE505P	Computer Networks Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To introduce the computer network concepts and provide skills required to trouble shoot the network devices.
2. To describe the basic knowledge of VLAN.
3. To develop the knowledge for application of software defined networks.

Course Outcome

1. Understand the types of network cables and practical implementation of cross-wired and straight through cable.
2. Design and implementation of VLAN.
3. Analyze and apply network address translation using packet tracer and network simulators.
4. Design and develop software defined networks.

Indicative Experiments

1.	Hardware Demo(Demo session of all networking hardware and Functionalities) OS Commands(Network configuration commands)
2.	Error detection and correction mechanisms Flow control mechanisms
3.	IP addressing Classless addressing
4.	Network Packet Analysis using Wireshark i. Packet Capture Using Wire shark ii. Starting Wire shark iii. Viewing Captured Traffic iv. Analysis and Statistics & Filters.
5.	Socket programming(TCP and UDP) Multi client chatting
6.	Networking Simulation Tool –Wired and Wireless
7.	SDN Applications and Use Cases
8.	Security in Network- Use cases
9	Performance evaluation of routing protocols using simulation tools.

Total Laboratory Hours | **30 hours**

Reference Books

1. James F. Kuross, Keith W. Ross, “Computer Networking, A Top-Down Approach”, 8th Edition(Paperback), Pearson Education, 2022.

Mode of Evaluation: CAT / Mid-Term Lab/ FAT

Recommended by Board of Studies	26-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCSE601L	Artificial Intelligence	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To establish theoretical knowledge and understanding in the field of Artificial Intelligence and identify its possible applications.
2. To plan and formulate a non-trivial problem as a state space and apply intelligent search algorithms to identify optimal solutions.
3. To develop and design methods to make decisions in complex uncertain environments.

Course Outcomes

At the end of the course the student will be able to

1. Understand the foundation of AI and apply various search algorithms to identify optimal solutions in state spaces.
2. Represent and reason with knowledge and uncertainty to identify solutions for real world problems.
3. Formulate plan as a state space and apply algorithms to find solutions.
4. To develop data driven learning agents.

Module:1	Intelligent Agents and Uninformed Search	6 hours

Foundations of Artificial Intelligence - Definitions - Evolution of AI - Applications of AI - Intelligent Agents - Agents and Environments - Nature of Environments - Structure of Agents- Solving Problem by Searching- Blind Search Techniques – Breadth First Search, Depth First Search, Uniform Cost Search, Iterative Deepening Search, Bidirectional search.

Module:2	Informed Search Algorithms	5 hours

Informed Search - Introduction to Heuristics – Greedy Breadth First Search, A* - Local Search Optimization Algorithms - Hill Climbing, Simulated Annealing.

Module:3	Optimal Search Algorithms	6 hours

Global optimization algorithms - Genetic Algorithms, Particle Swarm Optimization Algorithm, Ant Colony Optimization, Gravitational Search Algorithm - Games - Optimal Decisions in Games - Minimax Algorithm, Alpha-Beta Pruning Algorithm.

Module:4	Knowledge Representation and Reasoning	9 hours

Logical systems – Knowledge Based systems - Representing knowledge using Propositional Logic – Inference in Propositional Logic using Laws of Inference, Forward Chaining, Backward Chaining, Resolution. Representing knowledge using First Logic Order Logic- Inference in First Order Logic using Unification, Forward Chaining, Backward Chaining, Resolution.

Module:5	Quantifying Uncertainty	6 hours

Acting under Uncertainty, -Conditional Independence- Bayes Rule –Naïve Bayes Classifier - Bayesian Belief Network- Inference in Bayesian Belief Network- Making Decisions in Complex Environments- Markov Decision Processes.

Module:6	Classical Planning	6 hours

Planning Problem –STRIPS representation- Complexity of planning- Algorithms for Planning as State Space Search – Partial order Planning –Hierarchical Planning.

Module:7	Data Driven Learning Agents	5 hours

Forms of learning – Supervised Learning - Decision Trees – CART - Univariate Linear

Regression, Multivariate Linear Regression.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Russell, S and Norvig, P, 2015, Artificial Intelligence – A Modern Approach, 3rd Edition, Prentice Hall.
Reference Books	
1.	Min Xin-She Yang., "Nature-Inspired Computation and Swarm Intelligence Algorithms, Theory and Applications", Elsevier, Academic Press, 2020.
2.	Elaine Rich, Kevin Knight, Shivashankar B Nair., "Artificial Intelligence", 3rd Edition, McGraw Hill Education, 2017.
3.	Charu C. Aggarwal, "Data Classification: Algorithms and Applications", CRC Press, 2014.

Mode of Evaluation: CAT, Assignment, Quiz and FAT			
Recommended by Board of Studies	26-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCSE602L	Machine Learning	2	0	0	2
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. Acquire theoretical Knowledge on setting hypothesis for pattern recognition
2. Apply suitable machine learning techniques for data handling and knowledge extraction
3. Evaluate the performance of algorithms and to provide solutions for various real-world applications

Course Outcomes

1. Recognize the characteristics of machine learning strategies
2. Analyze and Apply the suitable supervised learning methods for real-world problems
3. Identify and integrate more than one technique to enhance the performance of learning
4. Create a suitable unsupervised learning model for handling unknown patterns
5. Design a model to handle large datasets with online learning

Module:1	**Introduction**	**4 hours**
PAC Learning-Consistent and inconsistent hypothesis, FIND-S, Candidate Elimination, deterministic and stochastic generalities, error, VC Dimensions, lower bounds-Convex optimization review- Probability review		
Module:2	**Dimensionality Reduction**	**4 hours**
Feature representation in different domains: text, image, video and audio, Feature selection: Filter, wrapper and embedded models, Feature Reduction: PCA, t-SNE		
Module:3	**Model Selection and Validation**	**3 hours**
Estimation and approximation errors: ERM-SRM- Validation- Regularization-based algorithms		
Module:4	**Classification Models**	**5 hours**
Supervised Learning , Perceptron – Single layer & Multi-layer – Linear SVM – Hard, Soft Margins, kernel Methods, Lazy SVM for Instance Based Learning, Handling imbalanced data: One Class SVM		
Module:5	**Ensemble Learning**	**3 hours**
Bagging-Committee Machines and Stacking-Boosting-Ranking based aggregation		
Module:6	**Clustering**	**5 hours**
Unsupervised Learning, Partitional Clustering-K-Means-Linkage-Based Clustering Algorithms-Birch Algorithm-CURE Algorithm-Density-based Clustering- Spectral Clustering.		
Module:7	**Online Learning**	**5 hours**
Online Classification in the Realizable Case- Online Classification in the Unrealizable Case-Online Convex Optimization- The Online Perceptron Algorithm- On-line to batch conversion – Federated Learning		
Module:8	**Contemporary Issues**	**1 hours**
	Total Lecture hours:	**30 Hours**

Text Book(s)

1	S. Shalev-Shwartz, S.Ben-David, “Understanding Machine Learning: From Theory to Algorithms”, Cambridge University Press, 2014.

Reference Books

1	Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar "Foundations of Machine Learning", MIT Press, 2nd Edition, 2018.
2	Duda, Richard, Peter Hart, and David Stork, "Pattern Classification," 2nd Edition, John Wiley & Sons, Hoboken, 2000.
3	Tom Mitchell, "Machine Learning", McGraw Hill, 3rd Edition, 1997.

Mode of Evaluation: CAT / Written Assignment / Quiz / FAT			
Recommended by Board of Studies	26-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCSE602P	Machine Learning Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. Acquire theoretical knowledge on setting hypothesis for pattern recognition.
2. Apply suitable machine learning techniques for data handling and knowledge extraction.
3. Evaluate the performance of algorithms and to provide solutions for various real-world applications.

Course Outcome

1. Identify suitable data pre-processing technique to apply on raw data to provide suitable input to various algorithms used for different purposes
2. Apply the suitable supervised learning methods for real-world problems
3. Identify and integrate more than one technique to enhance the performance of learning
4. Create a suitable unsupervised learning model for handling unknown pattern
5. Design a model to handle large datasets with online learning

Indicative Experiments

1.	Study of Machine Learning libraries in python
2.	Data exploration and preprocessing in machine learning
3.	Evaluate the classifier using various performance measures
4.	Implement a probabilistic model to detect Spam Email with Naive Bayes
5.	Implement regression algorithms to predict Stock Price
6.	Implement PCA and classify the hand-written digits.
7.	Implement a tree-based algorithm to predict ad click
8.	Classify newsgroup Topics with Support Vector Machines
9.	Implement multiclass classification for hand-written digits.
10.	Implement Bagging using Random Forests for hand written digits.
11.	Mining the 20 Newsgroups Dataset with Clustering and Topic Modeling Algorithms
12.	Training on large datasets with online learning
	Total Laboratory Hours | **30 hours**

Text Book(s)

1. Liu Yuxi, “Python Machine Learning By Example: Build intelligent systems using Python, TensorFlow 2, PyTorch, and scikit-learn”, 2020, 3rd Edition, Packt Publishing, UK.

Reference Books

1. Aurélien Géron, “Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems ", 2019, 2nd Edition, O'Reilly Media, Inc, United States.
2. Wes McKinney, “Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython", 2017, 2nd Edition, O'Reilly Media, Inc, United States.

Mode of Evaluation: CAT / Mid-Term Lab/ FAT

Recommended by Board of Studies	26-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCSE603L	Deep Learning	2	0	0	2
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

1. Introduce major deep neural network frameworks and issues in basic neural networks
2. To solve real-world applications using Deep learning
3. Providing insight into recent Deep Learning architectures

Course Outcomes

At the end of this course, students will be able to:

1. Understand the methods and terminologies involved in deep neural network, differentiate the learning methods used in Deep-nets.
2. Identify and improve Hyper parameters for better Deep Network Performance
3. To understand and visualize Convolutional Neural Network for real-world applications
4. To demonstrate the use of Recurrent Neural Networks and Transformer based for language modeling
5. To distinguish different types of Advanced Neural Networks

Module:1	Neural Networks	3 hours

The Neuron –Expressing Linear Perceptrons as Neurons – Feed-Forward Neural Networks – Linear Neurons and their Limitations – Sigmoid, Tanh and Relu Functions – Softmax Output Layers

Module:2	Neural Learning	4 hours

Measuring Errors - Gradient Descent – Delta Rule and Learning Rate – Backpropagation – Stochastic and Minibatch Gradient – Test Sets, Validation Sets and Overfitting – Preventing Overfitting in Deep Neural Networks – Other Optimization Algorithms: Adagrad, RMSProp, Adadelta, Adam

Module:3	Convolution Neural Networks	5 hours

Neurons in Human Vision – Shortcomings of Feature Selection –Scaling Problem in Vanilla Deep Neural Networks – Filters and Feature Maps – Description of Convolutional Layer – Maxpooling – Convolution Network Architecture – Image Classification

Module:4	Pre-Trained Models	3 hours

Self-Supervised Pretraining, AlexNet, VGG, NiN, GoogleNet, Residual Network (ResNet), DenseNet, Region-Based CNNs (R-CNNs) – Transfer Learning - FSL

Module:5	Recurrent Neural Networks	6 hours

Sequence-to-Sequence Modeling – Embedding - Recurrent Neural Networks - Bidirectional RNNs, Analyzing Variable Length Inputs – Tackling seq2seq Problem – Beam Search and Global Normalization – Recurrent Neural Networks (RNN)– Hidden States – Perplexity – Character-level Language Models –Modern RNNs: Gated Recurrent Units (GRU), Long Short Term Memory (LSTM), Bidirectional Long Short Term Memory (BLSTM), Deep Recurrent Neural Network, Bidirectional RNN

Module:6	Attention Models and Transformers	4 hours

Attention Mechanism: Attention Cues, Attention Pooling, Scoring Functions, Self-Attention and Positional Encoding;–Bidirectional Encoder Representations from Transformers (BERT) – Generative Pre-trained Transformers

Module:7	Advanced Neural Networks	4 hours

Generative Adversarial Networks – Generator, Discriminator, Training, GAN variants; Autoencoder: Architecture, Denoising and Sparcity; DALL-E, DALL-E 2 and IMAGEN

Module:8	**Contemporary Issues**	**1 hour**
	Total Lecture hours:	**30 Hours**

Text Book(s)	
1.	Fundamentals of Deep Learning, Nikhil Buduma and Nicholas Locasio, O-Reilly, 2017
2.	Dive into Deep Learning, Aston Zhang, Zachary C. Lipton, Mu Li, and Alexander J. Smola, Amazon Senior Scientists – Open source and Free Book, March 2022
Reference Books	
1.	Deep Learning, Ian Goodfellow Yoshua Bengio Aaron Courville, MIT Press, 2017
2.	Deep Learning: A Practitioner's Approach, Josh Patterson, Adam Gibson, O'Reilly Media, 2017

Mode of Evaluation: CAT / Written Assignment / Quiz / FAT			
Recommended by Board of Studies	26-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCSE603P	Deep Learning Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To understand deep neural network frameworks and learn to implement them
2. To learn to use pretrained models effectively and use them to build potential solutions

Course Outcomes

At the end of this course, student will be able to:

1. Understand the methods and terminologies involved in deep neural network, differentiate the learning methods used in Deep-neural nets.
2. Identify and apply suitable deep learning approaches for given application.
3. Design and develop custom Deep-nets for human intuitive applications
4. Design of test procedures to assess the efficiency of the developed model.
5. Apply and evaluate Pre-trained models to improve the models' performance.

Indicative Experiments

1.	Python Primer Revisiting Data Preprocessing Setting up Deep-Learning workstations Working with different data types and file formats	6 hours
2.	Simple Classification Tasks Working with MNIST – IMDB Datasets	4 hours
3.	Training a CNN from Scratch Using pretrained CNNs	6 hours
4.	Visualizing what CNNs are learning – Intermediate Activations, Convnet Filters, Heatmaps	2 hours
5.	Exploring Multi-Input, Multi-output Models Hyper-parameter Tuning	2 hours
6.	Language Modeling using RNN Practicing of Stacking Layers in Bidirectional RNNs	3 hours
7.	Transfer Learning models for classification problems Exploring Hugging-face API	2 hours
8.	Text Generation Using LSTM	2 hours
9.	Image generation from Text using GAN	3 hours
	Total Laboratory Hours	**30 hours**

Text Book(s)

1.	Deep Learning Step by Step with Python, N D Lewis, 2016
2	Neural Networks and Deep Learning, Michael Nielsen,, Determination Press

Reference Books

1.	Deep Learning: A Practitioner's Approach, Josh Patterson, Adam Gibson, O'Reilly Media, 2017
2.	Applied Deep Learning. A Case-based Approach to Understanding Deep Neural Networks, Umberto Michelucci, Apress, 2018.
3.	Deep Learning with TensorFlow: Explore neural networks with Python, Giancarlo Zaccone, Md. RezaulKarim, Ahmed Menshawy, Packt Publisher, 2017.

Mode of Evaluation: CAT / Mid-Term Lab/ FAT

Recommended by Board of Studies	26-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCSE604L	Speech and Natural Language Processing	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To introduce the concepts and techniques of Natural language processing for analyzing word sense based on part of speech and Constituency parsing.
2. To analyze speech signal in time and frequency domain.
3. To implement deep learning models covering a range of applications in speech recognition and text processing.

Course Outcomes

1. Describe the mathematical and linguistic foundations underlying approaches for NLP modules in Text processing and speech recognition.
2. Demonstrate the working of sequence models for text processing.
3. Use signal processing techniques to analyze and represent the speech signal.
4. Discuss statistical approach for automatic speech recognition including feature extraction, acoustic modeling and language modeling.
5. Develop a deep learning models associated with the design, implementation, training and deployment of speech and text processing.

Module:1	Language Model and Part-of-Speech	7 hours

Different Levels of NLP -Text Normalization - Minimum Edit Distance - N-gram Language Models – Smoothing - Huge Language Models - Perplexity's Relation to Entropy - Part-of-Speech Tagging – HMM for Part-of-Speech Tagging - Viterbi algorithm - Named Entities and Named Entity Tagging - Conditional Random Fields (CRFs) - Evaluation of Named Entity Recognition.

Module:2	Constituency Parsing and Lexical Semantics	6 hours

Introduction to Parsing - Linguistic Constituents and Constituency tests - Partial or Shallow Parsing - Dependency Parsing - Word Senses - Relations Between Senses - WordNet: A Database of Lexical Relations, Methods for Word Sense Disambiguation.

Module:3	Feature Representation for Natural Language Processing	6 hours

Vector Semantics - Words and Vectors - Cosine for measuring similarity -TF-IDF: Weighing terms in the vector - Pointwise Mutual Information (PMI) -Neural Language Models - Word Embedding's: Word2Vec, Glove and Fast text.

Module:4	Deep learning architecture for NLP	6 hours

RNNs as Language Models - Stacked and Bidirectional RNN architectures- LSTM - Self-Attention Networks: Transformers, Transformers as Language Models – Applications of NLP: Sentiment analysis, Question and answering, Chat Bot.

Module:5	Automatic Speech Recognition	7 hours

Introduction-Acoustic feature: Speech production, Raw Waveform, MFCC – Phones - Statistical Speech Recognition: Acoustic Models, Language Model, HMM Decoding – Error Metrics – DNN/HMM Hybrid – Text to Speech – WaveNet for Text to Speech.

Module:6	Transfer Learning and Domain Adaption	5 hours

Transfer Learning – Self-Taught Learning – Multitask Learning – Domain Adaption: Techniques, Theory - Applications in Speech Recognition- Zero-Shot Learning – One-Shot Learning - Few-Shot Learning.

Module:7	Deep Reinforcement Learning (DRL) for Text and Speech	6 hours

Connectionist Temporal Classification - Seq-to-Seq – End-to-End Decoding – Speech Embedding and Unsupervised Speech Recognition - Deep Reinforcement Learning – Reinforcement learning fundamentals – Deep Reinforcement Learning Algorithms – DRL for Text: Text Summarization, Machine Translation – DRL for Speech: Speech Enhancement and Noise Suppression.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Dan Jurafsky, James H. Martin "Speech and Language Processing", Draft of 3rd Edition, Prentice Hall 2022.
2.	Uday Kamath, John Liu, James Whitaker "Deep Learning for NLP and Speech Recognition", 1st Edition, Springer 2019.
Reference Books	
1.	Ben Gold, Nelson Morgan, Dan Ellis "Speech and Audio Signal Processing: Processing and Perception of Speech and Music", 2nd Edition, John Wiley & Sons, 2011.
2.	Jacob Benesty, M. M. Sondhi,Yiteng Huang "Springer Handbook of Speech Processing" , 1st Edition, Springer, 2008
Mode of Evaluation: CAT / Written Assignment / Quiz / FAT	

Recommended by Board of Studies	18-11-2022		
Approved by Academic Council	No. 68	Date	19-12-2022

.

Course Code	Course Title	L	T	P	C
MCSE605L	Machine Vision	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To impart the knowledge on image processing, segmentation and morphological operations on images.
2. To develop the ability to apprehend and implement various object identification, multi-camera views and depth estimation techniques.
3. To facilitate students to comprehend on various pattern and motion analysis schemes for machine vision applications.

Course Outcomes

At the end of this course, student will be able to:

1. Discover and understand enhancement, segmentation and morphological operations on images for further analysis.
2. Acquire the knowledge of various image transforms, wavelets and multiresolution analysis for better interpretation.
3. Experiment the various object identification techniques on images.
4. Design and implement various pattern analysis schemes for images.
5. Analyze and explore various multi-camera views and depth estimation techniques for motion analysis on video streams.

Module:1	Fundamentals of Image Processing and Enhancement	7 hours

Image Formation physics, Image Digitization – Sampling and Quantization, Digital Image Properties, Pixel relationship, Image Enhancement- Spatial filtering.

Module:2	Image Segmentation and Morphological operations	7 hours

Thresholding - Edge Based Segmentation – Region Based Segmentation- Active Contour Models.Dilation and Erosion – Opening, Closing – Hit or Miss Transform-Thinning-Thickening-Skeletons and object marking.

Module:3	Frequency domain and Multiresolution Analysis	5 hours

Frequency Domain filtering, Image transforms - Frequency domain transformations - DCT, DFT, FFT, DWT – Haar Wavelet - Multiresolution analysis - Scale-invariant features.

Module:4	Depth estimation and Multi-camera views	6 hours

Perspective, Binocular Stereopsis: Image Fusion, Camera and Epipolar Geometry; Homography, Rectification, DLT, RANSAC, 3-D reconstruction framework; Auto-calibration.

Module:5	Object Detection	7 hours

Detection of known objects by linear filters - Detection of unknown objects - The Hough transform for the detection of lines - Corner detection. Surface Descriptions, Shape from Contours, Shape from Shading, Shape from Texture.

Module:6	Pattern Analysis	6 hours

Clustering - K-Means - K-Medoids - Mixture of Gaussians, Classification - Discriminant Function, Supervised, Un-supervised, Semi-supervised; Classifiers – Bayes – KNN - ANN models; Application in Defect Analysis

Module:7	Motion Analysis	5 hours

Optical Flow – Detection and Correspondence of Interest Points - Detection of Motion Patterns – Video Tracking – Motion Models to aid tracking: Kalman Filters.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 Hours**
Text Book(s)		
1.	Milan Sonka, Vaclav Hlavac, Roger Boyle, "Image Processing, Analysis, and Machine Vision", 4th Edition, Cengage Learning, USA, 2014	
2.	Jurgen Beyerer, Fernando Puente Leon, Christian Frese,"Machine Vision Automated Visual Inspection: Theory, Practice and Applications", 2016, Springer.	
Reference Books		
1.	Oge Marques, Practical Image and Video Processing using MATLAB, IEEE Press, Wiley Publications, 2011	
2.	R. C. Gonzalez and R. E. Woods, "Digital Image Processing (4th Edition), 2018.	
3.	Computer Vision, A modern Approach by Forsyth and Ponce, Pearson Education, 2003.	
4.	R. Szeliski, "Computer vision: algorithms and applications", ISSN 1868-095X, 2nd Edition,Springer Nature Switzerland AG, 2022.	
5.	Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, 2nd Edition, Cambridge University Press, March 2004.	
6.	Christopher M. Bishop; Pattern Recognition and Machine Learning, Springer, 2006.	
Mode of Evaluation: CAT / Written Assignment / Quiz / FAT		
Recommended by Board of Studies	18-11-2022	
Approved by Academic Council	No. 68	Date 19-12-2022

Course Code	Course Title	L	T	P	C
MCSE606L	Cognitive Robotics	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To understand the science and technology behind cognitive thinking and to apply it on autonomous robots.
2. To understand advanced methods for creating efficient and dynamic cognitive robots.
3. To understand the recent literature, and collectively synthesize, clearly explain and evaluate the state of the art in cognitive robotics.

Course Outcomes

1. Understand the philosophy of cognition and architecture of cognitive systems used in robotics.
2. Apply various machine learning techniques to design, develop and control intelligent autonomous robots.
3. Design models to achieve autonomy of robots with the help of path planning, map building and localization techniques.
4. Develop robotic applications using various robot programming languages and tools.

Module:1	Introduction	6 hours

The nature of cognition Thinking, Aspects of Modelling Cognitive Systems Cognition, and Intelligence, Defining Intelligence and autonomy , Embodiment and Its Implications, Synthetic Methodology for Intelligence. Levels of Abstraction in Modelling Cognitive Systems.

Module:2	Cognitive Architectures and perception	6 hours

Definition, perspective of cognitive architecture, Desirable Characteristics, Designing a Cognitive Architecture, Example Cognitive Architectures, Introduction to the Model of Cognition, Visual Perception, Visual Recognition, Machine Learning, and Robot Cognition, Introduction to sensors and actuators.

Module:3	Intelligent System Design, Cognition Development and control	8 hours

Properties of Complete Agents, Agent Design Principle, Agent architectures, Developmental Robot Design, Matching brain and Body Dynamics, Artificial Neural Networks (ANN), Fuzzy Logic, Genetic Algorithms and Other Nature Inspired Methods, Optimal Control using ANN, Introduction to CNN.

Module:4	Autonomy and Map Building	7 hours

Types of Autonomy, Autonomic Systems, Different Scales of Autonomy, Measuring Autonomy, Autonomy and Cognition, A Menagerie of Autonomies ,Constructing a 2D World Map, Data Structure for Map Building, Explanation of the Algorithm, An Illustration of Procedure Map Building.

Module:5	Randomized Path Planning	7 hours

Introduction, Representation of the Robot's Environment, Review of configuration spaces, Visibility Graphs, Voronoi diagrams, Potential Fields and Cell Decomposition, Planning with moving obstacles, Probabilistic Roadmaps, Rapidly exploring random trees, Execution of the Quad tree-Based Path Planner Program.

Module:6	Simultaneous Localization and Mapping (SLAM)	5 hours

Problem Definition, Mathematical Basis, Examples: SLAM in Landmark Worlds, Taxonomy of the SLAM Problem, Extended Kalman filter, Graph-Based Optimization Techniques, Particle Methods Relation of Paradigms.		
Module:7	**Robot Programming methods**	**4 hours**
Python Robot Programming Methods-: Go-to-Goal Behavior, Avoid-Obstacles Behavior, Hybrid Automata (Behavior State Machine), Follow-Wall Behavior. A Complete Program for autonomous mobile robot.		
Module:8	**Contemporary Issues**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	David Vernon, "Artificial Cognitive Systems: A Primer" ,The MIT Press, 1st Edition,2014
2.	Patnaik, Srikanta, "Robot Cognition and Navigation – An Experiment with Mobile Robots", Springer Verlag Berlin and Heidelberg, 2007
Reference Books	
1.	HoomanSomani, "Cognitive Robotics", CRC Press, 2015
2.	Jared Kroff, "Cognitive Robotics: Intelligent Robotic Systems", Wilford Press, 2016
3.	Howie Choset, Kevin LynchSeth Hutchinson, George Kantor, Wolfram Burgard, Lydia Kavraki, and Sebastian Thrun, "Principles of Robot Motion-Theory, Algorithms, and Implementation", MIT Press, Cambridge, 2005.
Mode of Evaluation: CAT / Written Assignment / Quiz / FAT	

Recommended by Board of Studies	18-11-2022		
Approved by Academic Council	No. 68	Date	19-12-2022

Course Code	Course Title	L	T	P	C
MCSE607L	Game Programming	2	0	0	2
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To understand the processes, mechanics, issues in game design and game engine development
2. To understand modeling, techniques, handling situations and logic
3. To build and integrate technologies such as multimedia, artificial intelligence and physics-based modeling into a cohesive, interactive game application.

Course Outcomes

1. Design, develop, test, evaluate, debug, and modify code to meet design specifications for games.
2. Design unique gaming environments, levels and characters by choosing appropriate game strategies and patterns based on an analysis of past and present trends.
3. Design and develop a full-fledged computer game through animation principles and artificial intelligence.

Module:1	Introduction	3 Hours

Introducing the 10-Stage Workflow: Brainstorming, Initial Design: Game Overview, Game Details, Prototyping, Refining Design, and Project Management: Identify Resources - Compress Space - Schedule Work, Asset Creation, Importing Assets, Level Design, Scripting, Testing, Building, Recommendations for Working Practice.

Module:2	Gamming Environments	5 Hours

Configuring the Blender GUI: Dark Themes - Disable Python Tooltips - Exporting Blender Models to Unity: Blend Files - Exporting Manually to FBX, Exploring FBX Files, and Importing FBX Files into Unity: Light map UVs - Scale Factor.
Modular Environments and Static Meshes: Advantages of the Modular Method, Getting Started with Modular Environments in Blender - Extending from the Base Tile, Modular Environment Blender Workflow, UV Mapping and Texture Creation, Importing and Configuring Environments in Unity: Using Prefabs, Static Batching.

Module:3	Terrain	4 Hours

Creating Terrain in Unity: Terrain Settings - Sculpting Terrain -Texture-Painting Terrain, Evaluating Unity Terrains, Blender Terrain Modeling: The Proportional Editing Method - The Displacement-Texture Method - The Sculpting Method, Terrain Resolution, Texture-Painting Terrain: UV Mapping Terrains - Generating a Texture for Painting - Painting from the UV Image Editor - Painting from the 3D View - Painting with Textures , Working with Roads and Paths: Creating Roads.

Module:4	Physics based Game Modelling	3 hours

Basic Newtonian Mechanics- Forces: Gravitational Force, Friction, Centripetal Force, Basic Kinematics: The Relationship Between Force, Acceleration, Velocity and Location - Rigid Body Motion and Collision

Module:5	Animation workflows	5 Hours

Animation Units: The key frame, Preparing for Animation in Blender: Use a Dedicated Animation Layout - Beware of Auto-Key - Insert Single Key frames - Animation Length - Exporting Animations to FBX - Working with Multiple Animations,

Key frame Animations from Blender to Unity, Follow-Path Animations and Animation Baking, Blend Shapes and Shape Keys, Bones and Rigging: Always Name Bones - Use X-Axis Mirror for Character Rigs - Forward and Inverse Kinematics - Deform and Control Bones - Exporting Rigged Characters - Importing Rigged Meshes into Unity.		
Module:6	**Game Programming and Retopologizing**	**5 Hours**
Objects, Dependencies, and Event-Driven Programming: Hard-Coded Dependencies - Solving DI: Component-Based Design and Messages, Taking Messages Further: Broadcast Message and Hierarchies, Sending Messages to Selected Objects, Sending Messages to Parents, Notification System, Notifications Manager In-Depth, Singletons, Messages and Active Objects, Traversing Game Object Hierarchies. Retopologizing: High-Poly Meshes and Subdivision Surfaces, High-Poly Meshes and Real-Time Games - Retopologizing in Practice, Using Decimate.		
Module: 7	**AI for Games**	**3 Hours**
Model of Game AI: Decision Making, Strategy, Infrastructure and Agent-based AI; AI engine; Behavior authoring, Tree Search, Evolutionary Computation, Supervised Learning and Unsupervised Learning, Modeling Players.		
Module:8	**Contemporary Issues**	**1 Hour**
	Total Lecture hours:	**30 Hours**

Text Book(s)	
1.	Alan Thorn, Practical Game Development with Unity and Blender, Cengage Learning, 2015.
2.	Palmer G. Physics for game programmers. Berkeley: Apress; 2005
3	Artificial Intelligence and Games, Georgios N. Yannakakis and Julian Togelius, January 26, 2018, Springer
References Books:	
1	Sherrod A. Game Graphic Programming. Cengage Learning; 2008.
2	Artificial Intelligence for Games, 2nd Edition, Ian Millington and John Funge,2009
3	Akenine-Mo, T., Haines, E. and Hoffman, N., 2018. Real-time rendering
4	Fundamentals of Game Design, 3rd Edition, Ernest Adams, New Riders; 2013
5	Game Design Foundations, Second Edition, Roger E. Pedersen, Jones & Bartlett Learning; 2009
6.	Game Engine Architecture, 3rd Edition, Jason Gregory, A K Peters, 2019
Mode of Evaluation: CAT / Written Assignment / Quiz / FAT	

Recommended by Board of Studies	18-11-2022		
Approved by Academic Council	No. 68	Date	19-12-2022

Course Code	Course Title	L	T	P	C
MCSE607P	Game Programming Lab	0	0	2	1
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To understand the processes, mechanics, issues in game design, and game engine development
2. To understand modeling, techniques, handling situations, and logics
3. To build and integrate technologies such as multimedia, artificial intelligence, and physics modeling into a cohesive, interactive game application.

Course Outcomes

At the end of this course, student will be able to:

1. Classify different Sensors & Actuators based on various physical phenomena and learn various sensor calibration techniques
2. Select the relevant sensors and actuators to design real-time data acquisition from ambience via case studies

Indicative Experiments

1.	Game Programming - UNITY Basics	**2 Hours**
2.	Model Creation – 3D blender	**4 Hours**
3.	2D/ 3D Game environment	**4 Hours**
4.	Game environment creation	**2 Hours**
5.	Object motion simulation	**4 Hours**
6.	Deploying lighting effects	**2 Hours**
7.	Physics based game creation	**4 Hours**
8.	Creation of a Tile map based game	**2 Hours**
9.	Multiple Levels game development	**2 Hours**
10.	Game automation using AI	**4 Hours**
	Total Laboratory Hours	**30 hours**

Text Book(s)

1.	Alan Thorn, Practical Game Development with Unity and Blender, Cengage Learning, 2015.
2.	Game Engine Architecture, 3rd Edition, Jason Gregory, A K Peters, 2019
3.	Palmer G. Physics for game programmers. Berkeley: Apress; 2005
4.	Artificial Intelligence and Games, Georgios N. Yannakakis and Julian Togelius, January 26, 2018, Springer

Reference Books

1.	Sherrod A. Game Graphic Programming. Cengage Learning; 2008.
2.	McShaffry M. Game coding complete. Nelson Education; 2014
3.	Akenine-Mo, T., Haines, E. and Hoffman, N., 2018. Real-time rendering
4.	Fundamentals of Game Design, 3rd Edition, Ernest Adams, New Riders; 2013
5.	Game Design Foundations, Second Edition, Roger E. Pedersen, Jones & Bartlett Learning; 2009

Mode of Evaluation: CAT / Mid-Term Lab/ FAT

Recommended by Board of Studies	18-11-2022		
Approved by Academic Council	No. 68	Date	19-12-2022

Course Code	Course Title	L	T	P	C
MCSE698J	Internship I/ Dissertation I				10
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives:

To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field and also to give research orientation.

Course Outcome:

1. Considerably more in-depth knowledge of the major subject/field of study, including deeper insight into current research and development work.
2. The capability to use a holistic view to critically, independently and creatively identify, formulate and deal with complex issues.
3. A consciousness of the ethical aspects of research and development work.
4. Publications in the peer reviewed journals / International Conferences will be an added advantage.

Module Content **(Project duration: one semester)**

1. Dissertation may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
2. Dissertation should be individual work.
3. Carried out inside or outside the university, in any relevant industry or research institution.
4. Publications in the peer reviewed journals / International Conferences will be an added advantage.

Mode of Evaluation: Assessment on the project - Dissertation report to be submitted, presentation, project reviews and Final Oral Viva Examination.

Recommended by Board of Studies	26-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course Code	Course Title	L	T	P	C
MCSE699J	Internship II/ Dissertation II				12
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives:

To provide sufficient hands-on learning experience related to the design, development and analysis of suitable product / process so as to enhance the technical skill sets in the chosen field.

Course Outcome:

Upon successful completion of this course students will be able to

1. Formulate specific problem statements for ill-defined real life problems with reasonable assumptions and constraints.
2. Perform literature search and / or patent search in the area of interest.
3. Conduct experiments / Design and Analysis / solution iterations and document the results.
4. Perform error analysis / benchmarking / costing.
5. Synthesize the results and arrive at scientific conclusions / products / solution.
6. Document the results in the form of technical report / presentation.

Module Content **(Project duration: one semester)**

1. Dissertation may be a theoretical analysis, modeling & simulation, experimentation & analysis, prototype design, fabrication of new equipment, correlation and analysis of data, software development, applied research and any other related activities.
2. Dissertation should be individual work.
3. Carried out inside or outside the university, in any relevant industry or research institution.
4. Publications in the peer reviewed journals / International Conferences will be an added advantage.

Mode of Evaluation: Assessment on the project - Dissertation report to be submitted, presentation, project reviews and Final Oral Viva Examination.

Recommended by Board of Studies	26-07-2022		
Approved by Academic Council	No. 67	Date	08-08-2022

Course code	Course Title	L	T	P	C
MFRE501L	Français Fonctionnel	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. Demonstrate competence in reading, writing, and speaking basic French, including knowledge of vocabulary (related to profession, emotions, food, workplace, sports/hobbies, classroom and family).
2. Achieve proficiency in French culture oriented view point.

Course Outcome

At the end of the course, the student will be able to

1. Remember the daily life communicative situations via personal pronouns, emphatic pronouns, salutations, negations, interrogations etc.
2. Create communicative skill effectively in French language via regular / irregular verbs.
3. Demonstrate comprehension of the spoken / written language in translating simple sentences.
4. Understand and demonstrate the comprehension of some particular new range of unseen written materials.
5. Demonstrate a clear understanding of the French culture through the language studied.

Module:1	**Saluer, Se présenter, Etablir des contacts. Compétences en lecture - consulter un dictionnaire, appliquer des stratégies de lecture, lire pour comprendre.**	**9 hours**

Les nombres cardinaux- Les 7 jours de la semaine-Les 12 mois de l'année- La date-Les saisons-Les Pronoms personnels sujets-Les Pronoms Toniques- La conjugaison des verbes réguliers- er / - ir /-re verbes (Le présent)- La conjugaison des verbes irréguliers- avoir /être / aller / venir / faire /vouloir /pouvoir etc.

Savoir-faire pour: saluer, et se présenter – épeler en français – communiquer en classe – utiliser des stratégies pour comprendre un texte en français.

Module:2	**Présenter quelqu'un, Chercher un(e) correspondant(e), Demander des nouvelles d'une personne.**	**7 hours**

La conjugaison des verbes Pronominaux (s'appeler/ s'amuser/ se promener)- La Négation- L'interrogation avec 'Est-ce que ou sans Est-ce que'- Répondez négativement.

Module:3	**Situer un objet ou un lieu, Poser des questions**	**6 hours**

Les articles (défini/ indéfini)- Les prépositions (à/en/au/aux/sur/dans/avec etc.)- L'article contracté- L'heure- La Nationalité du Pays- Les professions- L'adjectif (La Couleur, l'adjectif possessif, l'adjectif démonstratif, l'adjectif interrogatif (quel/quelle/quels/quelles)- L'interrogation avec Comment/ Combien / Où etc., Pronoms relatifs simples (qui/que/dont/où).

Module:4	**Comprendre et traduire un texte court, Demander et indiquer le chemin.**	**5 hours**

La traduction simple d'un texte/ dialogue :(français-anglais / anglais –français)

Module:5	**Trouver les questions, Répondre aux questions générales en français, Écouter des vidéos (site internet, YouTube) qui aident à améliorer leur prononciation/ vocabulaire et leurs compétences orales**	**6 hours**

L'article Partitif (du/ de la / de l'/ des) -Faites une phrase avec les mots donnés- Mettez les phrases en ordre, masculin/féminin ; singulier/pluriel- Associez les phrases- les adverbes de temps (ensuite/hier/puis….)

Module:6	**Comment écrire un passage - développer des ompétences rédactionnelles. Discussion de groupe (donnez un sujet et demandez aux élèves de partager**	**5 hours**

	leurs idées)	
Décrivez La Famille -La Maison -L'université -Les Loisirs-La Vie quotidienne- La ville natale- Un personnage célèbre		
Module:7	**Comment écrire un dialogue**	**5 hours**
Dialogue a) Réserver un billet de train b) Entre deux amis qui se rencontrent au café c) Parmi les membres de la famille d) Entre le patient et le médecin e) Entre le professeur et l'étudiant(e)		
Module:8	**Contemporary Topics**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Adomania 1, Méthode de français, CelineHimber, Corina Brillant, Sophie Erlich. Publisher HACHETTE, February 2016.
2.	Enchanté 1 !, Méthode de français, Rachana Sagar Private Limited, Jan 2017.
Reference Books	
1.	Le français pour vous 1, Méthode de français, VinodSikri, Anna Gabriel Koshy, Prozopublishing, Jan 2019.
2.	Accueil 1, Méthode de français, Rachana Sagar Private Limited, January 2016
3.	Apprenons le français 1 Méthode de français, Mahitha Ranjit & Monica Singh, Jan 2019
Modeof Evaluation **:** Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test	

Recommended by Board of Studies	19-05-2022		
Approved by Academic Council	No. 66	Date	16-06-2022

Course code	Course Title	L	T	P	C
MGER501L	Deutsch für Anfänger	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. Demonstrate competency in reading, writing and speaking in Basic German.
2. Achieve proficiency in German culture oriented view point.
3. Develop basic vocabulary in the technical field.

Course Outcome

At the end of the course, the student will be able to

1. Communicate in German language in their daily life communicative situations.
2. Apply the German language skill in writing corresponding letters, E-Mailsetc.
3. Create the talent of translating passages from English-German and vice versa and to
   frame simple **dialogues** based on given situations.
4. Understand and demonstrate the comprehension of some particular new range of unseen
   written materials.
5. Develop a general understanding of German culture and society.

Module:1	Die erste Begegnung	6 hours

Einleitung, Begrüssungs formen, Länder und Sprachen, Alphabet, Buchstabieren, Personalpronomen, Zahlen (1-100), Telefonnummer und E-Mail Addressenennen W-fragen, Aussagesätze, Nomen – Singular und Plural und Artikel

Lernziel:

Verständnisvon Deutsch, Genus- Artikelwörter

Module:2	Hobbys und Berufe	6 hours

Über Hobbyssprechen, Wochentage, Jahreszeiten, und Monatenennen, Uhrzeitensagen, über Arbeit, Berufe und Arbeitszeitensprechen, Zahlen (Hundertbiseine Million) Aritel (bestimmter, unbestimmter), Plural der Substantive, Konjugation der Verben (regelmässig /unregelmässig), Ja-/Nein- Frage, Imperativmit Sie.

Lernziel :

Sätzeschreiben, überHobbyserzählen, über Berufesprechenusw.

Module:3	Alltag und Familie	7 hours

Über die Familiesprechen, eineWohnungbeschreiben, Tagesablaufschreiben, Mahlzeiten, Lebensmittel, Getränke Possessivpronomen, Negation, Kasus- Akkusativ und Dativ (bestimmter, unbestimmterArtikel), trennnbareverben, Modalverben, Adjektive, Präpositionen

Lernziel :

Sätzemit Modalverben, Verwendung von Artikel, über Familiesprechen, eine Wohnungbeschreiben.

Module:4	Situations gespräche	6 hours

Dialoge:

a) Gespräche mit Familienmitgliedern, am Bahnhof,
b) Gespräche beim Einkaufen, in einem Supermarkt, in einer Buchhandlung
c) Gespräche in einem Hotel/ in einem Restaurant, Treffen im Cáfe, Termin beim Arzt.

Module:5	Korrespondenz	6 hours

Leseverständnis, Mindmapmachen, Korrespondenz- Briefe, Postkarten, E-Mail

Lernziel :

Wortschatzbildung und aktiverSprachgebrauch

Module:6	Aufsatzschreiben	6 hours

Aufsätze :

Meine Universität, Das Essen, mein Freund odermeine Freundin, meine Familie, einFest in Deutschlandusw.

Module:7	Übersetzungen	6 hours

Übersetzungen : (Deutsch – Englisch / Englisch –Deutsch)

Lernziel :

Grammatik – Wortschatz – Übung		
Module:8	**Trainierung den Sprachfähigkeiten**	**2 hours**
	Total Lecture hours:	**45 hours**

Text Book(s)	
1.	Netzwerk A1, Stefanie Dengler, Paul Rusch, Helen Schmitz, Tanja Sieber, Ernst Klett Sprachen GmbH, Stuttgart, 2017
Reference Books	
1.	Studio d A1 Deutsch als Fremdsprache, Hermann Funk, Christina Kuhn, Silke Demme: Heuber Verlag, Muenchen, 2012.
2.	Lagune ,Hartmut Aufderstrasse, Jutta Müller, Thomas Storz,. Muenchen, 2012
3.	Deutsche SprachlehrefürAusländer, Heinz Griesbach, Dora Schulz, 2011, Berlin
4.	Themen Aktuell 1, Hartmurt Aufderstrasse, Heiko Bock, MechthildGerdes, Jutta Müller und Helmut Müller, 2010, Muenchen.
	www.goethe.de wirtschaftsdeutsch.de hueber.de, klett-sprachen.de www.deutschtraning.org

Mode of Evaluation **:** Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test			
Recommended by Board of Studies	19-05-2022		
Approved by Academic Council	No.66	Date	16-06-2022

Course Code	Course Title	L	T	P	C
MSTS601L	Advanced Competitive Coding	3	0	0	3
Pre-requisite	NIL	Syllabus version			
		1.0			

Course Objectives

1. To understand the basic concepts of data structures and algorithm.
2. To develop the step by step approach in solving problems with the help programming techniques of data structures.
3. To deploy algorithms in real time applications.

Course Outcomes

At the end of the course the student should be able to

1. Provide a basic understanding of core Java concepts
2. Use linear and non-linear data structures to solve practical problems.
3. Identify Bitwise algorithms for solving real world problems.
4. Illustrate various techniques for searching, sorting and hashing
5. Understand and implement Dynamic Programming.
6. Design new algorithms or modify existing algorithms for new application.

Module:1	Algorithms	6 hours

Java Introduction, Features, Structure, Data Types, Basic I/O Operators, Decision making and Control structure, Time & Space complexity

Module:2	Math based problems and Bitwise algorithms	6 hours

Simple Sieve, Segmented & Incremental Sieve, Euler's phi Algorithm, Strobogrammatic Number, Remainder Theorem, Toggle the switch & Alice Apple tree, Binary Palindrome, Booth's Algorithm, Euclid's Algorithm, Karatsuba Algorithm, Longest Sequence of 1 after flipping a bit Swap two nibbles in a byte.

Module:3	Arrays , Searching, Sorting and Strings	6 hours

Block Swap Algorithm , Max product subarray, Maximum sum of hour glass in matrix ,Max Equilibrium Sum ,Leaders in array, Majority element, Lexicographically first palindromic string, Natural Sort order , Weightes substring ,Move hyphen to beginning, Manacher's Algorithm

Module:4	Recursion, Back tracking, Greedy Algorithm	6 hours

Sorted Unique Permutation, Maneuvering, Combination, Josephus trap, Maze Solving, N Queens Problem, Warnsdorff's Algorithm, Hamiltonian Cycle, Kruskal's Algorithm ,Activity Selection Problem, Graph Coloring, Huffman Coding

Module:5	Dynamic Programming	6 hours

Longest Common Subsequence ,Longest Increasing Subsequence , Longest Bitonic Subsequence ,Longest Palindromic Subsequence ,Subset sum problem ,0-1 Knapsack, Traveling Salesman, Coin Change, Shortest Common, Supersequence, Levenshtein Distance problem, Rod Cutting problem, Wildcard pattern matching , Pots of gold game

Module:6	Linked list, Stack, Queue	6 hours

Loop Detection, Sort the bitonic DLL, Segregate even & odd nodes in a LL , Merge sort for DLL ,Minimum Stack, The Celebrity problem, Iterative Tower of Hanoi Stock

Span problem, Priority Queue using DLL, Sort without extra Space, Max Sliding Window, Stack permutations		
Module:7	**Trees, Graphs , Heaps, Maps**	**6 hours**
Recover the BST, Views of tree Vertical order traversal ,Boundary traversal, BFS, DFS, Dial's Algorithm ,Bellman-Ford Algorithm, Topological Sort ,Heap Sort Binomial heap, K-array heap, Winner tree, Hash Map to Tree Map.		
Module:8	**Interview Preparation**	**3 hours**
Networking, Security, Operating Systems, Data Base Management Systems.		
Total Lecture hours		**45 hours**

Text Book	
1.	Mark Allen Weiss, “Data structures and algorithm analysis in C++”, 2019, 4th Edition, Pearson Education.
Reference Books	
1.	J.P. Tremblay and P.G. Sorenson, “An Introduction to Data Structures with applications”, 2017, Second Edition, Tata Mc Graw Hill.
2.	Richard M. Reese, Jennifer L. Reese, Alexey Grigorev, Java: Data Science Made Easy, 2019 Pocket Publishing.
Mode of Evaluation: CAT, Written assignment, Quiz, Project & FAT.	

Recommended by Board of Studies	24-02-2023		
Approved by Academic Council	No. 69	Date	16-03-2023

Course code	Course Title	L	T	P	C
MENG501P	Technical Report Writing	0	0	4	2
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives

1.To develop writing skills for preparing technical reports.
2. To analyze and evaluate general and complex technical information.
3. To enable proficiency in drafting and presenting reports.

Course Outcome

At the end of the course, the student will be able to
1.Construct error free sentences using appropriate grammar, vocabulary and style.
2. Apply the advanced rules of grammar for proofreading reports.
3. Interpret information and concepts in preparing reports.
4. Demonstrate the structure and function of technical reports.
5. Improve the ability of presenting technical reports.

Indicative Experiments	
1.	**Basics of Technical Communication** General and Technical communication, Process of communication, Levels of communication
2.	**Vocabulary& Editing** Word usage: confusing words, Phrasal verbs Punctuation and Proof reading
3.	**Advanced Grammar** Shifts: Voice, Tense, Person, Number Clarity: Pronoun reference, Misplace and unclear modifiers
4.	**Elements of Technical writing** Developing paragraphs, Eliminating unnecessary words, Avoiding clichés and slang Sentence clarity and combining
5.	**The Art of condensation** Steps to effective precis writing, Paraphrasing and summarizing
6.	**Technical Reports:** Meaning, Objectives, Characteristics and Categories
7.	**Formats of reports and Prewriting**: purpose, audience, sources of information, organizing the material
8.	**Data Visualization** Interpreting Data - Graphs - Tables – Charts - Imagery - Info graphics
9.	**Systematization of Information:** Preparing Questionnaire Techniques to Converge Objective-Oriented data in Diverse Technical Reports
10.	**Research and Analyses:** Writing introduction and literature review, Reference styles, Synchronize Technical Details from Magazines, Articles and e-content
11..	**Structure of Reports** Title – Preface – Acknowledgement - Abstract/Summary – Introduction - Materials and Methods – Results – Discussion - Conclusion - Suggestions/Recommendations
12.	**Writing the Report:** First draft, Revising, Thesis statement, Developing unity and coherence
13.	**Writing scientific abstracts:** Parts of the abstract, Revising the abstract Avoiding Plagiarism, Best practices for writers
14.	**Supplementary Texts** Appendix – Index – Glossary – References – Bibliography - Notes
15	**Presentation**

	Presenting Technical Reports Planning, creating anddigital presentation of reports			
			Total Laboratory hours :	**60 hours**
Text Book(s)				
1.	Raman, Meenakshi and Sangeeta Sharma, (2015).Technical Communication: Principles and Practice, Third edition, Oxford University Press, New Delhi.			
Reference Books				
1.	Aruna, Koneru, (2020). English Language Skills for Engineers. McGraw Hill Education, Noida.			
2.	Rizvi,M. Ashraf (2018)Effective Technical Communication Second Edition. McGraw Hill Education, Chennai.			
3.	Kumar, Sanjay and Pushpalatha, (2018). English Language and Communication Skills for Engineers, Oxford University Press.			
4.	Elizabeth Tebeaux and Sam Dragga, (2020).The Essentials of Technical Communication, Fifth Edition, Oxford University Press.			
Mode of Evaluation **:** Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test				
Recommended by Board of Studies	19-05-2022			
Approved by Academic Council	No. 66	Date	16-06-2022	

Course Code	Course Title	L	T	P	C
MSTS501P	Qualitative Skills Practice	0	0	3	1.5
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives:

1. To develop the quantitative ability for solving basic level problems.
2. To improve the verbal and professional communication skills.

Course Outcome:

At the end of the course, the student will be able to

1. Execute appropriate analytical skills.
2. Solve problems pertaining to quantitative and reasoning ability.
3. Learn better vocabulary for workplace communication.
4. Demonstrate appropriate behavior in an organized environment.

Module:1	**Business Etiquette: Social and Cultural Etiquette; Writing Company Blogs; Internal Communications and Planning: Writing press release and meeting notes**	**9 hours**

Value, Manners- Netiquette, Customs, Language, Tradition, Building a blog, Developing brand message, FAQs', Assessing Competition, Open and objective Communication, Two way dialogue, Understanding the audience, Identifying, Gathering Information,. Analysis, Determining, Selecting plan, Progress check, Types of planning, Write a short, catchy headline, Get to the Point –summarize your subject in the first paragraph., Body– Make it relevant to your audience.

Module:2	**Time management skills**	**3 hours**

Prioritization, Procrastination, Scheduling, Multitasking, Monitoring, Working under pressure and adhering to deadlines

Module:3	**Presentation skills – Preparing presentation; Organizing materials; Maintaining and preparing visual aids; Dealing with questions**	**7 hours**

10 Tips to prepare PowerPoint presentation, Outlining the content, Passing the Elevator Test, Blue sky thinking, Introduction , body and conclusion, Use of Font, Use of Color, Strategic presentation, Importance and types of visual aids, Animation to captivate your audience, Design of posters, Setting out the ground rules, Dealing with interruptions, Staying in control of the questions, Handling difficult questions.

Module:4	**QuantitativeAbility-L1–Numberproperties; Averages; Progressions; Percentages; Ratios**	**11 hours**

Number of factors, Factorials, Remainder Theorem, Unit digit position, Tens digit position, Averages, Weighted Average, Arithmetic Progression, Geometric Progression, Harmonic Progression, increase and Decrease or Successive increase, Types of ratios and proportions.

Module:5	**Reasoning Ability - L1 – Analytical Reasoning**	**8 hours**

Data Arrangement (Linear and circular & Cross Variable Relationship), Blood Relations, Ordering / ranking / grouping, Puzzle test, Selection Decision table.

Module:6	**Verbal Ability -L1 – Vocabulary Building**	**7 hours**

Synonyms & Antonyms, One word substitutes, Word Pairs, Spellings, Idioms, Sentence completion, Analogies.		
	Total Lecture hours:	**45 hours**
Reference Books		
1.	Kerry Patterson, Joseph Grenny, Ron McMillan and Al Switzler, (2017).2nd Edition, Crucial Conversations: Tools for Talking when Stakesare High .McGraw-Hill Contemporary, Bangalore.	
2.	Dale Carnegie,(2016).How to Win Friends and Influence People. Gallery Books, New York.	
3.	Scott Peck. M, (2003). Road Less Travelled. Bantam Press, New York City.	
4.	SMART, (2018). Place Mentor, 1st edition. Oxford University Press, Chennai.	
5.	FACE, (2016). Aptipedia Aptitude Encyclopedia. Wiley publications, Delhi.	
6.	ETHNUS, (2013). Aptimithra. McGraw – Hill Education Pvt .Ltd, Bangalore.	
Websites:		
1.	**www.chalkstreet.com**	
2.	**www.skillsyouneed.com**	
3.	**www.mindtools.com**	
4.	**www.thebalance.com**	
5.	**www.eguru.ooo**	
Mode of Evaluation: Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test		
Recommended by Board of Studies	19-05-2022	
Approved by Academic Council	No.66	Date 16-06-2022

Course Code	Course Title	L	T	P	C
MSTS502P	Quantitative Skills Practice	0	0	3	1.5
Pre-requisite	Nil	Syllabus version			
		1.0			

Course Objectives:

1. To develop the students' advanced problem solving skills.
2. To enhance critical thinking and innovative skills.

Course Outcome:

At the end of the course, the student will be able to

1. Create positive impression during official conversations and interviews.
2. Demonstrate comprehending skills of various texts.
3. Improve advanced level thinking ability in general aptitude.
4. Develop emotional stability to tackle difficult circumstances.

Module:1	**Resume skills – Resume Template; Use of power verbs; Types of resume; Customizing resume**	**2 hours**

Structure of a standard resume, Content, color, font, Introduction to Power verbs and Write up, Quiz on types of resume, Frequent mistakes in customizing resume, Layout-Understanding different company's requirement, Digitizing career portfolio.

Module:2	**Interview skills – Types of interview; Techniques to face remote interviews and Mock Interview**	**3 hours**

Structured and unstructured interview orientation, Closed questions and hypothetical questions, Interviewers' perspective, Questions to ask/not ask during an interview, Video interview, Recorded feedback, Phone interview preparation, Tips to customize preparation for personal interview, Practice rounds.

Module:3	**Emotional Intelligence - L1 – Transactional Analysis; Brain storming; Psychometric Analysis; SWOT analysis**	**12 hours**

Introduction, Contracting, ego states, Life positions, Individual Brainstorming, Group Brainstorming, Stepladder Technique, Brain writing, Crawford's Slip writing approach, Reverse brainstorming, Star bursting, Charlette procedure ,Round robin brainstorming, Skill Test, Personality Test, More than one answer, Unique ways, SWOT analysis.

Module:4	**Quantitative Ability - L3–Permutation - Combinations; Probability; Geometry and menstruation; Trigonometry; Logarithms; Functions; Quadratic Equations; Set Theory**	**14 hours**

Counting, Grouping, Linear Arrangement, Circular Arrangements, Conditional Probability, Independent and Dependent Events, Properties of Polygon, 2D & 3D Figures, Area & Volumes, Heights and distances, Simple trigonometric functions, Introduction to logarithms, Basic rules of logarithms, Introduction to functions, Basic rules of functions, Understanding Quadratic Equations, Rules & probabilities of Quadratic Equations, Basic concepts of Venn Diagram.

Module:5	**Reasoning ability - L3 – Logical reasoning; Data Analysis and Interpretation**	**7 hours**

Syllogisms, Binary logic, Sequential output tracing, Crypto arithmetic, Data Sufficiency, Data Interpretation-Advanced, Interpretation tables, pie charts & bar chats.		
Module:6	**Verbal Ability - L3 – Comprehension and Critical reasoning**	**7 hours**
Reading comprehension, Para Jumbles, Critical Reasoning (a) Premise and Conclusion, (b) Assumption & Inference, (c) Strengthening & Weakening an Argument.		
	Total Lecture hours:	**45 hours**

Reference Books

1.	Michael Farra and JIST Editors,(2011).Quick Resume & Cover Letter Book: Write and Use an Effective Resume in Just One Day. Jist Works, Saint Paul, Minnesota.
2.	Flage Daniel E, (2003).The Art of Questioning: An Introduction to Critical Thinking. Pearson, London.
3.	David Allen, (2015).Getting Things done: The Art of Stress-Free productivity. Penguin Books, New York City.
4.	SMART, (2018). Place Mentor 1st edition. Oxford University Press, Chennai.
5.	FACE, (2016).Aptipedia Aptitude Encyclopedia. Wileypublications, Delhi.
6.	ETHNUS, (2013).Aptimithra. McGraw-Hill Education Pvt Ltd, Bangalore.

Websites:

1.	www.chalkstreet.com
2.	www.skillsyouneed.com
3.	www.mindtools.com
4.	www.thebalance.com
5.	www.eguru.ooo

Mode of Evaluation: Continuous Assessment Tests, Quizzes, Assignment, Final Assessment Test			
Recommended by Board of Studies	19-05- 2022		
Approved by Academic Council	No.66	Date	16-06-2022