Course Code: CSE-5203	**BNQF Code:** 06195203	**Credits**: 3.0 (3 Hours)
Course Title: Computational Intelligence		**Year:** 1st **Semester:** 2nd
Total Marks: 100		
Course Type: Core Course		
Pre-requisite: Artificial Intelligence, Probability & Statistics, Linear Algebra		

Rationale of the Course

Computational Intelligence (CI) is a subfield of Artificial Intelligence (AI) that focuses on adaptive and bio-inspired problem-solving techniques such as neural networks, fuzzy logic, and evolutionary algorithms. These methods are widely applied in optimization, machine learning, robotics, pattern recognition, and decision-making under uncertainty. This course provides students with theoretical knowledge and practical skills to design, analyze, and implement CI techniques for real-world problems.

Course Objectives

1. To introduce the principles and methods of computational intelligence.
2. To explore fuzzy logic systems for reasoning under uncertainty.
3. To provide understanding of neural networks and deep learning foundations.
4. To study evolutionary computation, genetic algorithms, and swarm intelligence.
5. To apply CI techniques in optimization, control, pattern recognition, and decision support systems.

Course Contents

Introduction to Computational Intelligence: Definition, scope, differences from classical AI.

Fuzzy Logic: Fuzzy sets, membership functions, fuzzy rules, fuzzy inference systems, applications.

Neural Networks: Perceptron, multilayer networks, backpropagation, deep learning basics.

Evolutionary Computation: Genetic algorithms, genetic programming, applications.

Swarm Intelligence: Particle swarm optimization (PSO), ant colony optimization (ACO).

Hybrid Computational Intelligence: Neuro-fuzzy systems, evolutionary neural networks.

Applications in Optimization: Scheduling, routing, resource allocation.

CI in Pattern Recognition: Image processing, natural language processing.

CI in Robotics & Control Systems: Adaptive control, self-learning robots.

Recent Trends: Reinforcement learning, deep neuro-evolution, ethical issues.

Course Learning Outcomes (CLO): (at the end of the course, student will be able to:)

CLO1	Recall the basic principles and methods of computational intelligence.
CLO2	Explain fuzzy logic systems and apply them to reasoning problems.
CLO3	Construct and train artificial neural networks for learning tasks.
CLO4	Apply evolutionary and swarm intelligence algorithms to optimization problems.
CLO5	Evaluate the effectiveness of CI techniques in real-world applications.

Mapping of Course Learning Outcomes (CLO) to Program Learning Outcomes (PLO)

CLO → PLO	**PLO1**	**PLO2**	**PLO3**	**PLO4**	**PLO5**	**PLO6**	**PLO7**	**PLO8**	**PLO9**	**PLO10**
CLO1	✓	✓								
CLO2		✓	✓							
CLO3			✓	✓	✓					
CLO4				✓	✓	✓				
CLO5					✓		✓	✓	✓	✓

Teaching-Learning Strategies (TLS)

TLS1	Interactive lectures with multimedia/animations.
TLS2	Problem-solving and mathematical modeling sessions.
TLS3	Hands-on demonstrations with robot simulators/ROS.
TLS4	Group discussions and case studies.
TLS5	Student presentations and mini-projects.

Assessment Strategies (AS)

AS1	Quiz
AS2	Class Test
AS3	Assignment
AS4	Presentation
AS5	Midterm
AS6	Group Discussion
AS7	Final Exam

Mapping of Course Learning Outcomes (CLOs) with the Teaching -Learning and Assessment Strategies

Couse Plan

Week	Lesson	Discussion Topic	TLS	AS	CLO Mapping
1	1	Introduction to Computational Intelligence	TLS1	AS6	CLO1
	2	CI vs Classical AI	TLS1	AS6	CLO1
2	3	Fuzzy Sets & Membership Functions	TLS1	AS3	CLO2
	4	Fuzzy Inference Systems & Applications	TLS1, TLS2	AS3	CLO2
3	5	Neural Networks: Perceptron & MLP	TLS1, TLS2	AS3	CLO3
	6	Backpropagation Algorithm	TLS2	AS3	CLO3
4	7	Deep Learning Basics	TLS1, TLS2	AS6	CLO3
	8	Midterm Review & Class Test	TLS1	AS2	CLO1–CLO3
5	9	Evolutionary Computation: GA Concepts	TLS1	AS6	CLO4
	10	Genetic Programming & Applications	TLS1, TLS2	AS6	CLO4
6	11	Swarm Intelligence: Particle Swarm Optimization	TLS1, TLS2	AS3	CLO4
	12	Ant Colony Optimization	TLS1	AS3	CLO4
7	13	Hybrid CI Systems: Neuro-Fuzzy	TLS1, TLS2	AS6	CLO3, CLO4
	14	Evolutionary Neural Networks	TLS1, TLS2	AS6	CLO3, CLO4
8	15	CI in Optimization Problems	TLS3	AS6	CLO4
	16	Group Discussion: Optimization	TLS3	AS6	CLO4

		in Industry			
9	17	CI in Pattern Recognition	TLS1, TLS4	AS4	CLO5
	18	CI in NLP & Image Processing	TLS1, TLS4	AS4	CLO5
10	19	CI in Robotics & Control Systems	TLS1	AS6	CLO5
	20	Case Studies on CI Applications	TLS4	AS6	CLO5
11	21	Student Presentations	TLS5	AS4	CLO5
	22	Project Guidelines (CI project)	TLS2, TLS4	AS7	CLO3–CLO5
12	23	Project Work: CI-based application	TLS2, TLS4	AS7	CLO3–CLO5
	24	Quiz & Recap	TLS1	AS1	CLO1–CLO5
13	25	Review Class	TLS1–TLS5	AS6	CLO1–CLO5
14	26	Midterm Exam	-	AS5	-
15–16	Preparatory Leave	-	-	-	
17–23	Final Exam	-	-	-	

Recommended Books:

6. Engelbrecht, A. P. *Computational Intelligence: An Introduction*. Wiley.
7. Jang, J. S. R., Sun, C. T., & Mizutani, E. *Neuro-Fuzzy and Soft Computing*. Prentice Hall.
8. Goldberg, D. E. *Genetic Algorithms in Search, Optimization and Machine Learning*. Addison-Wesley.
9. Kennedy, J., Eberhart, R., & Shi, Y. *Swarm Intelligence*. Morgan Kaufmann.
10. Haykin, S. *Neural Networks and Learning Machines*. Pearson.

Assessment and Evaluation

1. Before Final [40 marks]

Bloom's Level	Attendance (5)	Quiz (5)	Assignment (5)	Presentation (5)	Midterm (20)	Total
Remember	1	2	1	1	5	10
Understand	2	2	2	2	7	15
Apply		1	2	2	8	13
Analyze						
Evaluate						
Create						

2. Final Exam [60 marks]

Bloom's Criteria	Score for the Test
Remember	10
Understand	20
Apply	15
Analyze	10
Evaluate	5
Create	-

Course Code: CSE-5204	**BNQF Code:** 06195204	**Credits**: 1 (2 Hours)
Course Title: Computational Intelligence Lab		**Year:** 1st **Semester:** 2nd
Total Marks: 100		
Course Type: Core Course (Lab)		
Pre-requisite: Artificial Intelligence, Probability & Statistics, Programming		

Rationale of the Course

Computational Intelligence (CI) encompasses nature-inspired problem-solving techniques such as neural networks, fuzzy logic, and evolutionary algorithms. This lab provides students with hands-on skills in applying CI algorithms to real-world problems such as optimization, pattern recognition, classification, and decision-making. It prepares students for research and industry applications in AI, machine learning, and optimization.

Course Objectives

- To provide practical experience with computational intelligence paradigms.
- To apply neural networks, fuzzy systems, and evolutionary algorithms to real-world problems.
- To develop problem-solving skills using optimization and learning techniques.
- To evaluate and compare different CI methods in terms of accuracy, performance, and robustness.
- To implement CI-based mini projects and applications.

Course Contents

Introduction to CI Tools: Python, MATLAB, TensorFlow, or Scikit-learn.

Artificial Neural Networks (ANNs): Implementation of perceptron, MLP, and backpropagation.

Fuzzy Logic Systems: Designing fuzzy sets, rules, and inference systems.

Genetic Algorithms (GA): Encoding, selection, crossover, mutation, and optimization.

Swarm Intelligence: Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO).

Hybrid CI Techniques: Combining fuzzy, neural, and evolutionary methods.

Applications: Classification, regression, image recognition, scheduling, decision support.

Mini Project: Implementing a CI-based solution for a real-world problem.

Course Learning Outcomes (CLO): (at the end of the course, student will be able to:)

CLO1	Describe the principles of computational intelligence paradigms.
CLO2	Implement basic neural network, fuzzy logic, and evolutionary algorithms.
CLO3	Apply CI techniques to solve optimization, classification, and decision-making problems.
CLO4	Analyze and compare the performance of CI methods for different applications.
CLO5	Design and implement a CI-based mini project for a real-world application.

Mapping of Course Learning Outcomes (CLO) to Program Learning Outcomes (PLO)

CLO	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10
CLO1	✓	✓								
CLO2		✓	✓	✓						
CLO3			✓	✓	✓	✓				
CLO4		✓	✓	✓	✓	✓	✓			
CLO5			✓	✓	✓	✓	✓	✓	✓	✓

Teaching-Learning Strategies (TLS)

TLS1	Hands-on programming and simulations using Python/MATLAB.
TLS2	Guided problem-solving sessions
TLS3	Group work on CI-based projects.
TLS4	Code review and continuous mentoring.

Assessment Strategies (AS)

AS1	Viva
AS2	Lab Report
AS3	Lab Assessment
AS4	Lab Final

Mapping of Course Learning Outcomes (CLOs) with the Teaching -Learning and Assessment Strategies

Couse Plan

Week	Lab Topics	TLS	AS	CLO Mapping
1	Introduction to CI tools (Python/MATLAB/Scikit-learn)	TLS1, TLS2	AS3, AS4	CLO1
2	Implementing perceptron and multilayer neural networks	TLS1, TLS2	AS3, AS4	CLO2
3	Backpropagation algorithm and training datasets	TLS1, TLS2	AS3, AS4	CLO2
4	Designing fuzzy sets and membership functions	TLS1, TLS3	AS3, AS4	CLO2
5	Fuzzy rule base and inference system	TLS1, TLS3	AS3, AS4	CLO2, CLO3
6	Genetic algorithms – selection, crossover, mutation	TLS1, TLS3	AS3, AS4	CLO2, CLO3
7	Lab Assessment (based on Lab 1–6)	-	AS4	-
8	Particle Swarm Optimization (PSO) implementation	TLS1, TLS3	AS3, AS4	CLO3
9	Ant Colony Optimization (ACO) implementation	TLS1, TLS3	AS3, AS4	CLO3
10	Hybrid CI techniques (neuro-fuzzy or GA+NN)	TLS1, TLS3	AS3, AS4	CLO3, CLO4
11	CI applications in classification and regression	TLS1, TLS3	AS3, AS4	CLO3, CLO4
12	CI applications in scheduling, routing, decision support	TLS1, TLS3	AS3, AS4	CLO3, CLO4
13	Lab Assessment (based on Lab 7–12)	-	AS4	-
14	Mini project development and review	TLS2, TLS3, TLS4	AS3, AS4	CLO5
15	Preparatory Leave	-	-	-
16-18	Final Project / Viva	-	AS5	CLO1–CLO5

Text Books

1. S. N. Sivanandam, S. N. Deepa – *Principles of Soft Computing*
2. Simon Haykin – *Neural Networks and Learning Machines*
3. Jacek Zurada – *Introduction to Artificial Neural Systems*

Reference Books

1. James Kennedy & Russell Eberhart – *Swarm Intelligence*
2. David Goldberg – *Genetic Algorithms in Search, Optimization, and Machine Learning*
3. Online resources: TensorFlow, PyTorch, Scikit-learn tutorials

Assessment and Evaluation

1. Before Final [40 marks]

Bloom's Criteria	Attendance (10)	Lab Report (10)	Lab Assessment (20)	Total
Remember		2	4	8
Understand		3	5	11
Apply		4	7	14
Analyze		1	4	7
Evaluate		-	-	0
Create		-	-	0
Total	10	10	20	40

2. Final Exam [60 marks]

Bloom's Criteria	Lab Performance/Viva (20)	Project Report (10)	Final Project (30)	Total
Remember	3	2	5	10
Understand	4	2	8	14
Apply	5	2	10	17
Analyze	5	2	5	12
Evaluate	2	2	2	6
Create	1	-	-	1
Total	20	10	30	60