Title (Units): **COMP4056 Nature-Inspired Computing (3,2,1)**

Course Aims: This interdisciplinary Computer Science course provides an introduction to some interesting concepts, principles, and applications of computing, which are inspired by processes and phenomena found in nature, such as biological evolution, interactions (e.g., cooperation and competition) in ecosystems, and behavior in living organisms. It offers students opportunities to appreciate those concepts, develop new insights and methods, and turn them into practical problem-solving and modeling applications, e.g., from World-Wide Web search to scheduling.

Prerequisite: COMP2015 Data Structures and Algorithms
MATH1205 Discrete Mathematics

Course Intended Learning Outcomes (CILOs):
Upon successful completion of this course, students should be able to:

No.	Course Intended Learning Outcomes (CILOs)
	Knowledge
1	Describe the needs for present and future computing paradigm changes with examples found in the real world
2	Describe the underlying nature inspired principles, as well as the basic formulations and implementation of nature inspired computing (NIC) approaches in the contexts of problem-solving and modeling
3	Explain the nature and characteristics of case study problems or applications, as well as the key ideas and steps in applying NIC methods
4	Explain the similarities and differences among NIC methods, and their general applicability
	Professional Skill
5	Design, implement, and evaluate suitable NIC methods to solve problems and model systems in the real-world contexts
	Attitude
6	Exhibit a strong interest in pursuing interdisciplinary studies

Calendar Description: This interdisciplinary Computer Science course provides an introduction to some interesting concepts, principles, and applications of computing, which are inspired by processes and phenomena found in nature. It offers students opportunities to appreciate those concepts, develop new insights and methods, and turn them into practical problem-solving and modeling applications.

Teaching and Learning Activities (TLAs):

CILOs	Type of TLA
1-4	Students will acquire the concepts via lectures and practice them in class.
5-6	Students will develop their NIC-based problem-solving skill and attitude through various phases of a project and assignments.

Assessment:

No.	Assessment Methods	Weighting	CILOs to be addressed	Description of Assessment Tasks
1	Continuous Assessment	50%	5-6	The continuous assessment consists of assignments and a mini-project that are designed to provide opportunities for students to demonstrate their understanding of some nature inspired computing methods taught through performing problem-solving and modeling tasks.
2	Examination	50%	1-4	Final examination questions will evaluate students' knowledge and understanding of key NIC concepts and principles as well as problem-solving and modeling methods, as introduced in the lectures.

				The evaluation will assess the extent to which the students achieve the expected CILOs.

Assessment Rubrics:

Excellent (A)	• Achieves all the first five LOs, with strong evidence of having achieved the last LO, demonstrating a good mastery of both the theoretical and practical aspects of the knowledge and skills associated with nature inspired computing (NIC) • Able to develop and present sound arguments and correct solutions to problems, accompanied by in-depth analysis and insight • Demonstrates a thorough understanding and solid knowledge of NIC concepts, principles, and applications • Able to draw on a variety of techniques and relevant knowledge and appropriately apply them to new NIC situations and problems
Good (B)	• Achieves all the first five LOs, and evidence of having achieved the last LO, demonstrating a good understanding of the associated concepts and underlying methodologies • Able to develop solutions to problems, accompanied by adequate explanations • Demonstrates a competent level of knowledge of NIC concepts, principles, and applications • Ability to make use of appropriate techniques and knowledge and apply them to familiar situations and problems
Satisfactory (C)	• Achieves most of the first five LOs, demonstrating a basic level of understanding of the associated concepts and underlying methodologies • Able to provide acceptable solutions to problems • Demonstrates an adequate level of knowledge of NIC concepts, principles, and applications • Ability to make use of some techniques and knowledge and apply them to familiar situations
Marginal Pass (D)	• Achieves most of the first five LOs, with minimal understanding of the associated concepts and underlying methodologies • Able to provide solutions to simple problems • Demonstrates a basic level of knowledge of NIC concepts, principles, and applications • Ability to apply some techniques and knowledge to a limited number of typical situations
Fail (F)	• Achieves less than three of the LOs, with little understanding of the associated concepts and underlying methodologies • Unable to provide solutions to simple problems • Knowledge of NIC concepts, principles, and applications falling below the basic minimum level • Unable to apply techniques or knowledge to situations or problems

Course Content and CILOs Mapping:

Content		CILO No.
I	Nature Inspired Computing for Problem-Solving	1-4,6
II	Nature Inspired Computing for Modeling	1-4,6
III	Introduction to NIC Computers	1,2,6
IV	Examples of Case Studies and Applications	1-6
V	Continuous Assessment	5-6

References:

- D. Floreano and C. Mattiussi, Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies, MIT Press, Cambridge, MA, 2008.

- L. Kari and G. Rozenberg, ″The many facets of natural computing,″ Communications of the ACM, Volume 51, Issue 10, Pages 72-83, October 2008.
- L. Nunes de Castro, Fundamentals of Natural Computing: Basic Concepts, Algorithms, and Applications, Chapman and Hall/CRC, Boca Raton, Florida, 2006.
- L. Nunes de Castro, ″Fundamentals of Natural Computing: An Overview,″ Physics of Life Reviews, Volume 4, Issue 1, Pages 1-36, March 2007.

Course Content:

Topic

I. Nature Inspired Computing for Problem-Solving
  A. Artificial neural networks
  B. Artificial immune systems
  C. Swarm intelligence
  D. Evolutionary algorithms
  E. Ant colony optimization
  F. Particle swarm optimization
  G. Diffusion search

II. Nature Inspired Computing for Modeling
  A. Artificial lifelike forms and behavior
  B. Creative evolutionary art
  C. Foraging and satisficing
  D. Autonomous self-organizing systems
  E. Competition and cooperation
  F. Collective/crowd behavior
  G. Social trend and consensus

III. Introduction to NIC Computers
  A. Cellular automata
  B. Biological computers
  C. Quantum computers

IV. Examples of Case Studies and Applications
  A. How local search helps you develop a personalized portfolio
  B. How DNA computes a path for a traveling salesman
  C. How an artificial immune system learns and cluster customer data
  D. How computers learn new concepts, just like our brains
  E. How artificial life creates future “living” digital arts
  F. How evolutionary computers automatically program for you
  G. How artificial spiders immunize and protect our computers or email networks
  H. How ants, birds, and fish compute to find their foods together in nature
  I. How people socially meet and form interesting communities on the Internet
  J. What earthquake and World-Wide Web have in common

V. Continuous Assessment