Course Code: ELE-605
Course Title: Neuromorphic Computing
Number of Credits: 04 **Total Hours: 60** **Total Marks: 100**
Effective from AY: 2022-23

Prerequisites for the course		
Graduate level knowledge in analog and digital electronics. Preferable to have exposure to programming.		
Objectives of Course		
This course is intended to: • Introduce Neuromorphic computing and spiking neural networks (SNN). • Introduce operational principles and learning models for Artificial Neural Networks and Spiking Neural Networks • Cover various Neuromorphic computing architectures		
Course Content		
Unit I	**Introduction**	**7 Hours**

Basics of brain-inspired computing and history of neural computing, Comparison of neuromorphic and conventional computing, Basics of linear algebra and probability theory needed for modelling of neural networks.		
Unit II	**Shallow neural networks**	**17 Hours**
Deep learning techniques using convolutional neural networks(AlexNet, VGG, Inception Net, GoogLeNet, and ResNet), Python programming preliminaries and Software development tools for Deep Neural Net (DNN), Shallow neural networks – Perceptron, Hopfield network, Boltzmann machine, Recurrent neural network, and Kohonen's self-organizing map		
Unit III	**Operational principles and learning models**	**17 Hours**
Operational principles and learning models for Artificial Neural Networks and Spiking Neural Networks(SNN) such as spike timing dependent plasticity (STDP), Q-learning, actor-critic reinforcement learning, supervised learning, and back-propagation algorithms.		
Unit IV	**Neuromorphic computing architectures**	**11 Hours**
Neuromorphic computing architectures- Loihi, TrueNorth, Neurogrid, Brainchip and SpiNNaker, Commercial hardware acceleration platforms such as NVDIA's graphics processing unit (GPU), Google's tensor processing unit (TPU), and Intel's vision processing unit (VPU) and FPGA accelerators.		
Unit V	**Applications and Emerging technologies**	**8 Hours**
Application-specific VLSI chips capable of STDP learning, actor/critic reinforcement learning, and Q-learning, Emerging technologies in neuromorphic circuits such as memristors, spin transfer torque devices, and photonic devices.		
Case Studies		
1. Setup of python environment for implementation of Spiking neural network(SNN) 2. Implementation of SNN for Image classification 3. Implementation of SNN for pattern recognition. 4. Handwritten digit recognition Using STDP		
Pedagogy		
lectures/ Experiential Learning		
Course Outcome		

Students will,

- Apply concepts of neuromorphic computing in research as well as industry in various applications such as computer vision, speech processing, pattern recognition etc.
- The student will be able to pursue research in development of neruromorphic hardware.

References/Readings

1. Nan Zheng and Pinaki Mazumder, "Learning in Energy-Efficient Neuromorphic Computing: Algorithm and Architecture Co-Design", John Wiley & Sons, USA, 2019.
2. Aaron C. Courville, Ian Goodfellow, and Yoshua Bengio, " Deep Learning", MIT Press, 2015.
3. Pinaki Mazumder, Yalcin Yilmaz, Idongesit Ebong, "Neuromorphic Circuits for Nanoscale Devices", River Publishing, 2019.