# BACHELOR'S DEGREE PROGRAMME

## B.Tech.

## Computer Science and Engineering with Specialization in Artificial Intelligence

## Academic Curricula

## 2024-2028

**SCHOOLOFCOMPUTERENGINEERING**

**KALINGAINSTITUTEOF INDUSTRIAL TECHNOLOGY**
**BHUBANESWAR – 751024**

**ODISHA, INDIA**

## Programme Specific Outcome (PSO)

- Understand, analyze and develop essential proficiency in the areas related to artificial intelligence in terms of underlying statistical and computational principles and apply the knowledge to solve practical problems
- Ability to implement Artificial Intelligence techniques such as search algorithms, neural networks, machine learning, and data analytics for solving a problem and designing novel algorithms for successful career and entrepreneurship
- Use modern tools and techniques in the area of Artificial Intelligence

## Guideline and Notes to obtain the Specialization

A student has to follow the B.Tech Computer Science curricula. To get the specialization the student has to take the following as the professional electives in the respective semester from the basket.

| **PE: Professional Elective** | | | | |
|---|---|---|---|---|
| **PE** | **CourseCode** | **Course Title** | **Pre-requisites** | **Credits** |
| PE I | | Any one Subject from PE- I Basket of CSE Syllabus. | | 3 |
| PE II | | Any one Subject from PE- II Basket of CSE Syllabus. | - | 3 |
| PE III | CS30016 | Natural Language Processing | | 3 |
| PE IV | CS40001 | Deep Learning Techniques | | 3 |
| PE V | CS40016 | Generative AI and Large Language Models / Machine Learning Operations | | 3 |

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|---|---|
| **Course Title** | **Natural Language Processing** |
| **Course Code (Credit)** | **CS30016 (L-T-P-Cr: 3-0-0-3)** |
| **Pre-requisites** | **CM30006** |

**Course Objectives:**

- To understand the steps involved in Natural language processing
- Tolearnaboutthelexical,syntacticandsemanticanalysisofnaturallanguageprocessing
- To explore the various parsing techniques for natural languages
- To understand the statistical models for Natural language processing
- TolearnaboutthevariousapplicationsinvolvedinNaturallanguageprocessing

**Course Contents:**

**UNITI**

Lexical Analysis: Lexical Analysis, Regular expression and Automata for string matching, Words and Word Forms, Morphology fundamentals, Morphological Diversity of Indian Languages, Morphology Paradigms, Finite State Machine, Transducers Based Morphology, Automatic Morphology Learning, Parts of Speech, N-gram Models, HiddenMarkovModels.*****

**UNITII**

Speech Processing: Biology of Speech Processing, Place and Manner of Articulation, Word Boundary Detection, Argmax based computations, HMM and Speech Recognition, Text to Speech Synthesis, Rule based, Concatenative based approach.

**UNITIII**

Parsing: Theories of Parsing, Parsing Algorithms, Earley Parser, CYK Parser, Probabilistic Parsing, CYK, Resolving attachment and structural ambiguity, Shallow Parsing, Dependency Parsing, Named Entity Recognition, Maximum Entropy Models, ConditionalRandomFields.*

**UNITIV**

Lexical Knowledge Networks: Lexical Knowledge Networks, Word net Theory, Indian Language Word nets and Multilingual Dictionaries, Semantic Roles, Word Sense Disambiguation,WSDandMulti-linguality,Metaphors,Coreference and Anaphora Resolution.*

**UNITV**

Applications:

Sentiment Analysis, Text Entailment, Machine Translation, Question Answering System, Information Retrieval, Information Extraction Cross Lingual Information Retrieval(CLIR).

**Course Outcomes:**

Upon completion of the course, the students will beable to:

CO1:Evaluatedifferentcomputingarchitecturesfornaturallanguageprocessing forvariousparameters

CO2: Justify the various steps necessary for processing natural language

CO3:Suggest appropriate lexical and parsing techniques for a given natural language

CO4:Apply appropriate statistical models for a given natural language application

CO5: Modify existing algorithms to suit any natural language for processing

CO6:Suggest appropriate pre-processing steps essential for the various applications involving natural language processing

**Textbooks:**

1. ChristopherManning,SchutzeHeinrich,"FoundationsofStatisticalNatural LanguageProcessing",MITPress, 1999.

**ReferenceBooks:**

1. AllenJames,"NaturalLanguageUnderstanding",SecondEdition,BenjaminC umming,1995.

| Course Title | Deep Learning Techniques |
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| CourseCode (Credit) | CS40001 (L-T-P-Cr: 3-0-0-3) |
| Pre-requisites | CS31001 |

**Course Objectives:**

- To introduce building blocks of deep neural network architecture
- To learn deep learning algorithms and its problem settings
- To understand representation and transfer of knowledge using deep learning
- To learn to use deep learning tool sand framework for solving real-life problems
- To use Python for Deep Learning

**Course Contents:**

**UNIT I**

**Deep Networks:**

Deep Feed forward Networks, Learning XOR, Gradient Based learning, Hidden Units, Back-propagation and other Differential Algorithms, Regularization for Deep Learning, Optimization for training Deep Models.

**UNIT II**

**Convolutional Networks:**

Convolution operation, Motivation, Pooling, Convolution and Pooling as strong prior, Efficient convolution algorithms, Unsupervised features, Sequence Modeling: Recurrent and Recursive Nets, LSTM Networks, Applications, Computer Vision, Speech Recognition, Natural Language Processing.

**UNIT III**

**Linear factor Models:**

Probabilistic PCA and Factor Analysis, Independent Component Analysis (ICA), Auto encoders, Regularized Auto-encoders, Representational Power, Layer size and Depth, Stochastic Auto encoders, Applications.

**UNIT IV**

**Representation Learning:**

Greedy Layer-wise Unsupervised Pre-Training, Transfer learning and

Domain Adaptation, Deep Generative Models.

**UNITV**

**Deep Learning with Python:**

IntroductiontoKerasandTensorflow,DeepLearningforcomputervision,convnets,DeepLearningforTextandSequences, Generative Deep Learning, Text Generation with LSTM, Deep Dream, Neural Style Transfer, Generating images with variational auto encoders, Generative Adversarial Networks(GAN).

**Course Outcomes:**

Upon completion of this course, the students will be able to:

CO1: Assess the concept of deep learning

CO2:Identifythedeeplearningalgorithmswhicharemoreappropriateforvarioustypesoflearningtasksinvariousdomains

CO3: Incorporate transfer of knowledge in machine learning algorithms

CO4: Implement deep-learning algorithms and solve real-world problems

CO5: Develop Deep Learning techniques using Python

CO6: Represent learning Models

**Textbooks:**

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, DeepLearning", The MIT Press, 2016.

**Reference Books:**

1. Francois Chollet, "Deep Learning with Python ", Manning Publications, 2017.
2. Aurélien Géron, "Hands-On Machine Learning with Scikit-Learnand Tensor Flow: Concepts, Tools, and Techniques to Build Intelligent Systems", FirstEdition,O'ReillyMedia,2017.
3. Josh Patterson, "Deep Learning: A Practitioner's Approach", First Edition, O'Reilly Media.

| Course Title | Generative AI and Large Language Models |
|---|---|
| CourseCode(Credit) | CS40016 (L-T-P-Cr: 3-0-0-3) |
| Pre-requisites | Python, Deep Learning |

**Course Objectives:**

- To introduce a generative foundation model
- To learn custom applications using large language models (LLMs)
- To employ advanced techniques to generate models
- To enhance software development through artificial intelligence and deep learning advancements
- To use Python and its tools for model building

**Course Contents:**

**UNIT I**

Generative AI Fundamentals: "Drawing" Data from Models, Applications of AI, Probability Rules and Bayes' Theorem, Requirements of Generative Models, Style Transfer and Image Transformation, Challenges of Generative Models. Building Blocks of Deep Neural Networks: Perceptrons, Multi-layer Perceptrons and Back propagation, Convolution and Recursive Networks for Seeing, Convolutional Architectures, CNNs, AlexNet and its Architecture, CNN Innovations, RNNs and LSTMs, Optimization Algorithms – Gradient Descent, ADAM, AdaGrad, Nesterov Momentum, Xavier Initialization.

**UNIT II**

Teaching Networks to Generate Digits: Retrieving and Loading Database, Modeling data with uncertainty, Boltzmann Machines, Hopefield Networks, Deep Belief Networks, Creating RBM, Creating DBN.

Painting Pictures with Neural Networks Using VAEs: Variational Auto encoders (VAEs), Encodings of Images, Reparameterization Tricks, Inverse Autoregression, Importing Some Benchmark Dataset (CIFAR), Creating Networks using TensorFlow2.

**UNIT III**

Image Generation with GANs: Generative Adversarial Networks (GANs)- Taxonomy, the discriminator model, the generator model, Training GANs. Vanilla GAN, Deep Convolutional GAN, Conditional GAN, Wasserstein GAN,

Progressive GAN, Challenges.
Style Transfer with GANs:Paired style transfer using pix2pix GAN – The U-Net generator, The Patch-GAN discriminator, Loss, Training pix2pix GAN, Use cases. Unpaired style transfer using Cycle GAN–Adversial loss, Cycle loss, Identity loss, Overall loss. DiscoGAN, DualGAN.
Deep fakes with GANs: Overview, Facial Action Coding System (FACS), 3D Morphable Model, Facial Landmarks detection, Workflow, Replacement using auto-encoders, Re-enactment using pix2pix, Ethical and Technical Challenges.

**UNIT IV**

Methods for Text Generation:Representing Text – Bag of Words, Distributed representation, Word2vec, GlovVe, FastText. LSTMs and Language Modeling (Character-level), Decoding Strategies – Greedy decoding, Beam Search, Sampling. Stacked LSTMs, Bidirectional LSTMs. Transformers, GPT.

**UNIT V**

Composing Music with Generative Models: Music generation using LSTMs, GANS; Polyphonic music generation – Jamming model, Composer model, Hybrid model, Temporal model. Composing Video with Generative AI and Applications: Reinforcement learning, Inverse reinforcement learning, Adversarial learning.
Recent research in generative AI, spanning biotechnology, fluid mechanics, video, and text synthesis.

**Course Outcomes:**

Upon completion of this course, the students will be able to:

CO1: Understand the fundamentals of Deep Neural Networks
CO2: Learn the models to generate digits and photographs using GANs
CO3: Use GANs to generate Images and videos with different types
CO4: Implementing generation models, and integrate different features to it.
CO5: Generate texts, and paragraphs for certain specific situations
CO6: Represent GANS using Python and Deep Learning tools

**Textbooks:**

1. Joseph Babcock and Raghav Bali, Generative AI with Python and TensorFlow2: Create images, text, and music with VAEs, GANs, LSTMs, Transformer models, Packt Publishing Limited (2021),

**Available online**:

https://www.scribd.com/document/721021741/Generative-AI-with-Python-and-TensorFlow-2-Create-images-text-and-music-with-VAEs-GANs-LSTMs-Transformer-models-Joseph-Babcock-Raghav-Bali-Z

**Reference Books:**


1. AltafRehmani, Generative AI for everyone: Understanding the essentials and applications of this breakthrough technology, Bluerose Publishers Pvt. Ltd., 2024.
2. AurélienGéron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems, Third Edition, O'Reilly Publisher, 2022.


**Reference Online Source:**

1. https://onlinecourses.swayam2.ac.in/imb24_mg116/course#registration_confirmation

| **Course Title** | **Machine Learning Operations** |
|---|---|
| **Course Code(Credit)** | **CS40018(L-T-P-Cr: 3-0-0-3)** |
| **Pre-requisites** | |

**CourseObjectives:**

- Tointroduce Machine Learning Models, Architectures and Patterns
- Tolearn MLOPs Infrastructures and different tools for implementation
- Toget a deep understanding of MLOPs packaging process and deployment in different environments
- To integrate ML models through CI/CD/CT pipelines and their developments
- Todeploy the ML models in different scenarios for monitoring, testing, evaluation, and improvement.

**Course Contents:**

**UNIT I**

**Introduction to MLOPs:**

Principles of MLOPs, Best Practices, MLOPs Strategy, Enterprising MLOPs, Challenges; Architecture and Components – Components (Data source, data versioning, data analysis, code repository, Pipeline orchestration,

Model training and storage, Model deployment and serving, Monitoring, Feature processing); Architecture (Minimum, Production, Enterprise); Deployment patterns; Combining Developments, Staging and Production environment.
Git and GitHub Fundamentals.

**UNIT II**

**MLOPs Infrastructure and Tools**.
Storage, Computer, Containers, Orchestration, Machine Learning Platforms; MLOPs-based Machine Learning Systems (Initial, Transition, Operations), Machine Learning Development (Cookiecutter, Repository structure).
ML Life Cycle, Management of ML Life Cycle.

**UNIT III**

**Packaging ML Models:**
MLOPs Code Repository, Data Sourcing, Data Analysis, Model Development, Machine Learning Systems, Data Preparation, Model Development, Model Evaluation, Model Versioning, Developing the Package;

Deploying ML Models on different platforms – Heroku, Microsoft Azure, Google Cloud Platform, Amazon Web Services (Basic Concepts).

**UNIT IV**

**MLflow – Platform to Manage the ML Life Cycle:**
MLflow tracking, Projects, Models, Model Registry; Continuous Integration, Continuous Deployment, and Continuous Testing (CI/CD/CT) Pipelines using Jenkins, GitHub Actions, Continuous Training, Retraining, and Delivery;
**Continual Learning** - Requirements, Principles, Stateless and Stateful Training, Challenges; ML Life Cycle, Dockers for ML, Building ML Web Apps using API, Building ML Native Apps

**UNIT V**

**Deployment of ML Models:**
CI/CD for ML, Deploying ML Models on different platforms – Heroku, Microsoft Azure, Google Cloud Platform, Amazon Web Services (Implementation); Monitoring and debugging the deployed models. Deployment Strategies (Single, Silent, Canary, Multi-armed bandits), Model Inference and Serving
**Post Productionizing ML Models:**

Continuous Monitoring – Principles of Model Drift, Model Transparency, Significance of Monitoring; MLOPs Workflow – Logging, Model Evaluation, testing, and evaluation; Frameworks for Model Monitoring, Integrating with Tools. Model Security.

**Course Outcomes:**

Uponcompletionofthiscourse,thestudentswillbeableto:

CO1: Understand MLOPs process and environments
CO2: Learn the usage of ML tools during the life cycle of ML Models
CO3: Develop ML models and learn their packaging for deployment
CO4: Acquainted with different platforms for ML Model deployment and their life cycle.
CO5: Generate prototypes of ML models through continuous retraining, testing, evaluating, and improvements
CO6: Analyze and ensure the ML Model security for production

**Textbooks:**


1. Suhas Pote, Machine Learning in Production: Master the art of delivering robust Machine Learning solutions with MLOPs– BPB Publication, First Edition, 2023.
2. Chip Huyen, Designing Machine Learning Systems: An Iterative Process for Production-Ready Applications (Grayscale Indian Edition), O'Reilly.


**ReferenceBooks:**


1. Andrew McMahon, Machine Learning Engineering with Python - Second Edition: Manage the lifecycle of machine learning models using MLOps with practical examples, Packt Publication.
2. Mark Treveil , Nicolas Omont, Introducing MLOps: How to Scale Machine Learning in the Enterprise (Grayscale Indian Edition), O'Reilly.
3. Yaron Haviv and Noah Gift, Implementing MLOps in the Enterprise: A Production-First Approach (Grayscale Indian Edition), SPD Publication.
4. Raman Jhajj, Mastering MLOPs Architecture : From Code to Deployment – BPB Publication, First Edition, 2024