# Python / ML

## Python Programming Fundamentals

- **Python Basics**
  - Data Types, Variables, and Operators
  - Control Flow: if, else, for, while loops
  - Functions and Lambda Expressions
  - Exception Handling
  - File Handling and I/O Operations
- **Advanced Python Concepts**
  - Object-Oriented Programming (OOP) in Python
  - Decorators, Iterators, and Generators
  - Context Managers
  - Python Modules and Packages
  - Working with Dates and Times in Python
- **Data Structures and Algorithms in Python**
  - Lists, Tuples, Sets, and Dictionaries
  - Stacks, Queues, Linked Lists, Trees, and Graphs
  - Searching and Sorting Algorithms
  - Recursion and Dynamic Programming
  - Algorithm Complexity: Big-O Notation

## Data Handling and Manipulation

- **NumPy for Numerical Computing**
  - Creating and Manipulating Arrays
  - Broadcasting and Vectorized Operations
  - Mathematical and Statistical Functions
  - Working with Multi-dimensional Arrays
  - Advanced Array Operations
- **Pandas for Data Manipulation**
  - Series and DataFrame Objects
  - Data Cleaning and Preparation
  - Handling Missing Data
  - Merging, Joining, and Concatenating DataFrames
  - Grouping and Aggregating Data
- **Data Visualization with Matplotlib and Seaborn**
  - Creating Plots and Charts with Matplotlib
  - Customizing Plots: Titles, Labels, Legends
  - Advanced Plots: Heatmaps, Pair Plots, and Facet Grids
  - Interactive Visualizations with Plotly
  - Data Visualization Best Practices

## Machine Learning Fundamentals

- **Introduction to Machine Learning**
  - Overview of Machine Learning: Supervised, Unsupervised, Reinforcement Learning
  - Bias-Variance Tradeoff
  - Evaluation Metrics: Accuracy, Precision, Recall, F1-Score, ROC-AUC
  - Cross-Validation and Model Selection
  - Data Preprocessing: Feature Scaling, Encoding, Normalization
- **Supervised Learning**
  - **Linear Regression**
    - Simple and Multiple Linear Regression

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        - Regularization Techniques: Lasso, Ridge, ElasticNet
        - Polynomial Regression
        - Evaluating Regression Models
    - **Classification Algorithms**
        - Logistic Regression
        - k-Nearest Neighbors (k-NN)
        - Support Vector Machines (SVM)
        - Decision Trees and Random Forests
        - Naive Bayes Classifier
    - **Ensemble Methods**
        - Bagging and Boosting Techniques
        - Gradient Boosting Machines (GBM)
        - XGBoost, LightGBM, and CatBoost
        - Stacking and Blending Models
- **Unsupervised Learning**
    - **Clustering Algorithms**
        - k-Means Clustering
        - Hierarchical Clustering
        - DBSCAN (Density-Based Spatial Clustering)
        - Gaussian Mixture Models (GMM)
    - **Dimensionality Reduction**
        - Principal Component Analysis (PCA)
        - Linear Discriminant Analysis (LDA)
        - t-SNE and UMAP
        - Feature Selection and Extraction Techniques
    - **Anomaly Detection**
        - Statistical Methods for Anomaly Detection
        - Isolation Forest
        - Autoencoders for Anomaly Detection
        - Applications of Anomaly Detection
- **Reinforcement Learning**
    - Basics of Reinforcement Learning
    - Markov Decision Processes (MDPs)
    - Q-Learning and Deep Q-Networks (DQNs)
    - Policy Gradient Methods
    - Applications of Reinforcement Learning in Industry

## Deep Learning with Python

- **Introduction to Neural Networks**
    - Basics of Neural Networks and Perceptrons
    - Activation Functions: ReLU, Sigmoid, Tanh
    - Forward and Backward Propagation
    - Loss Functions and Optimization: Gradient Descent, Adam
    - Overfitting and Regularization: Dropout, Batch Normalization
- **Deep Learning Frameworks**
    - **TensorFlow 2.x**
        - Building and Training Models with Keras API
        - Customizing Models and Layers
        - Handling Large Datasets with tf.data
        - Model Deployment with TensorFlow Serving
    - **PyTorch**
        - Building and Training Models in PyTorch
        - Autograd and Dynamic Computation Graphs

        - Transfer Learning with Pre-trained Models
        - Implementing Custom Loss Functions and Layers
    - **Advanced CNN Architectures**
        - Convolutional Neural Networks (CNNs) Basics
        - Advanced Architectures: ResNet, Inception, EfficientNet
        - Object Detection with YOLO and SSD
        - Image Segmentation with U-Net and Mask R-CNN
        - Practical Applications: Computer Vision Projects
- **Natural Language Processing (NLP)**
    - Text Preprocessing: Tokenization, Stemming, Lemmatization
    - Word Embeddings: Word2Vec, GloVe, FastText
    - Sequence Models: Recurrent Neural Networks (RNNs), LSTMs, GRUs
    - Attention Mechanism and Transformers
    - Advanced NLP with BERT, GPT, and T5
    - Sentiment Analysis, Text Classification, and Machine Translation
- **Generative Models**
    - Variational Autoencoders (VAEs)
    - Generative Adversarial Networks (GANs)
        - Conditional GANs, CycleGANs
        - Image Synthesis and Style Transfer
    - Applications of Generative Models

## Model Deployment and Productionization

- **Model Serving and APIs**
    - Building RESTful APIs for Model Serving
    - Deploying Models with Flask, FastAPI
    - Model Deployment on AWS, Azure, GCP
    - Containerization with Docker for Model Deployment
    - Scaling Models in Production
- **MLOps: Machine Learning Operations**
    - Continuous Integration/Continuous Deployment (CI/CD) for ML
    - Model Monitoring and Performance Tracking
    - Automating Model Retraining Pipelines
    - Data Versioning and Experiment Tracking with MLflow
    - End-to-End MLOps Platforms: Kubeflow, TFX

## Advanced Topics and Industry Applications

- **Time Series Forecasting**
    - ARIMA, SARIMA Models
    - LSTM for Time Series Forecasting
    - Prophet for Time Series Analysis
    - Advanced Forecasting Techniques
- **Recommender Systems**
    - Collaborative Filtering and Matrix Factorization
    - Content-Based Filtering
    - Hybrid Recommender Systems
    - Deep Learning for Recommender Systems
- **Computer Vision Projects**
    - Face Recognition and Emotion Detection
    - Autonomous Vehicles: Object Detection and Lane Detection
    - Medical Imaging: Disease Detection and Diagnosis
- **AI Ethics and Fairness**

- Bias and Fairness in Machine Learning Models
- Explainability and Interpretability of Models
- Ethical Considerations in AI Deployment
- Regulatory Compliance and Governance

## Capstone Projects

- **End-to-End Machine Learning Project**
  - Data Collection, Cleaning, and Preprocessing
  - Model Building, Tuning, and Evaluation
  - Model Deployment and Monitoring in Production
  - Documentation and Reporting of the Project
- **Domain-Specific Projects**
  - Finance: Fraud Detection, Stock Price Prediction
  - Healthcare: Predictive Modeling, Personalized Medicine
  - Retail: Customer Segmentation, Demand Forecasting
  - Social Media: Sentiment Analysis, Trend Prediction