**Unit I: Foundations of Deep Learning (6 Hours)**

This unit lays the groundwork for understanding deep learning.

**Key Topics:**

1. **Introduction:**
   * **What is Machine Learning (ML) and Deep Learning (DL):**
     + ML: Algorithms that allow computers to learn from data.
     + DL: A subset of ML using neural networks with many layers (deep architectures).
   * **History of Deep Learning:**
     + Evolution from perceptrons to deep networks; milestones like ImageNet, AlphaGo.
   * **Advantages and Challenges:**
     + Advantages: Automatic feature extraction, scalability.
     + Challenges: Overfitting, data requirements, interpretability.
2. **Core Concepts:**
   * **Learning Representations from Data:** DL learns hierarchical features.
   * **Structure of a Neural Network:**
     + Input layer → Hidden layers → Output layer
   * **Architectural Principles:**
     + Depth of networks, types of layers, modular design.
   * **Applications:** NLP, CV, Robotics, Healthcare, Gaming.
3. **Hyperparameters:**
   * **Learning Rate:** Controls weight update size.
   * **Regularization:** Prevents overfitting (L1/L2).
   * **Momentum:** Accelerates SGD.
   * **Sparsity, Hidden Units, Cost Functions:** Model complexity and performance.
4. **Optimization:**
   * **Error Backpropagation:** Computes gradients of weights.
   * **Gradient Descent:** Optimization algorithm.
   * **Variants:**
     + **SGD:** Stochastic Gradient Descent.
     + **AdaGrad, RMSProp, Adam:** Adaptive learning rates.
   * **Challenges:**
     + **Vanishing/Exploding Gradients:** Affects deep networks.

**Case Studies:**

* **DeepMind**, **AlphaGo**, **Boston Dynamics**, **Amazon Go Store**

**Unit II: Deep Neural Networks (DNNs) (6 Hours)**

Focuses on the structure and function of basic and deep neural networks.

**Key Topics:**

1. **Introduction to Neural Networks:**
   * **Biological Neuron vs Artificial Neuron**
   * **Perceptron Model:** Logic gates (AND, OR, NOT, XOR)
2. **Deep Feedforward Networks:**
   * **Multilayer Feed-Forward Networks**
   * **Training:**
     + **Forward Propagation:** Computes output.
     + **Backpropagation:** Updates weights using error.
3. **Activation Functions:**
   * **Linear**
   * **Sigmoid, Tanh, Hard Tanh**
   * **ReLU (Rectified Linear Unit)**
   * **Softmax (for classification)**
4. **Loss Functions:**
   * **Notation & Purpose**
   * **For Regression:** MSE, MAE
   * **For Classification:** Cross-entropy
   * **For Reconstruction:** Autoencoders (e.g., MSE)

**Case Study:**

* **Music Genre Classification**

**Unit III: Convolutional Neural Networks (CNN) (6 Hours)**

Covers image processing with CNNs.

**Key Topics:**

1. **CNN Architecture:**
   * Inspired by the visual cortex.
   * Local receptive fields, shared weights.
2. **Building Blocks:**
   * **Convolutional Layers:** Feature extraction.
   * **Padding & Strides:** Controls output size.
   * **ReLU Layer:** Introduces non-linearity.
   * **Pooling Layer:** Reduces dimensionality (Max Pooling, Average Pooling).
   * **Fully Connected Layer:** For final decision making.
   * **Interleaving Layers:** Stack of conv+ReLU+pooling.
3. **Normalization:**
   * **Local Response Normalization (LRN)**: Boosts generalization.
4. **Training CNNs:**
   * Backprop through conv and pooling layers.

**Case Studies:**

* **AlexNet**, **VGG**

**Unit IV: Recurrent Neural Networks (RNN) (6 Hours)**

Focuses on sequential data and memory in neural networks.

**Key Topics:**

1. **Basics of RNNs:**
   * **Unfolding Computational Graphs**
   * Sequence modeling using loops in networks.
2. **Types of RNNs:**
   * **Bidirectional RNNs**
   * **Encoder-Decoder Architectures (e.g., Machine Translation)**
   * **Recursive Neural Networks**
3. **Challenges:**
   * **Long-Term Dependencies**
   * **Vanishing Gradients**
4. **Solutions:**
   * **LSTM (Long Short-Term Memory)**
   * **Gated RNNs (GRU)**
   * **Echo State Networks**
   * **Leaky Units**
5. **Optimization Techniques:**
   * Choosing right metrics, default baselines, and tuning hyperparameters.

**Case Studies:**

* **Multi-digit recognition**, **Google**, **Bing**, **DuckDuckGo**

**Unit V: Deep Generative Models (8 Hours)**

Learn to generate new data using deep learning.

**Key Topics:**

1. **Overview of Generative Models:**
   * Models that generate synthetic data similar to real data.
2. **Types of Generative Models:**
   * **Boltzmann Machines**
   * **Deep Belief Networks (DBNs)**
   * **GANs (Generative Adversarial Networks):**
     + **Discriminator:** Classifies real/fake.
     + **Generator:** Creates fake data.
     + **Types:** Vanilla GAN, DCGAN, CycleGAN, etc.
3. **Applications of GANs:**
   * Image generation, super-resolution, deepfakes, etc.

**Case Studies:**

* **GAN for image authenticity**, **ChatGPT (generative model use case)**

**Unit VI: Reinforcement Learning (6 Hours)**

Teaches how agents learn through interaction with environments.

**Key Topics:**

1. **Introduction to RL:**
   * **Deep RL:** Combines deep learning with RL.
2. **Markov Decision Process (MDP):**
   * Framework for modeling decision-making.
   * States, actions, rewards, transitions.
3. **RL Concepts:**
   * **Exploration vs Exploitation**
   * **Reward Functions**
4. **Algorithms:**
   * **Dynamic Programming (DP)**
   * **Q-Learning:** Value-based.
   * **Deep Q-Networks (DQN)**
   * **Deep Q-Recurrent Networks (DQRN)**
5. **Simple Applications:**
   * **Tic-Tac-Toe**, Game playing agents.

**Case Studies:**

* **Self-driving Cars**

**Unit I: Introduction to BI and Decision Support System (6 Hours)**

**Business Intelligence (BI):**

* **Definition**: BI refers to technologies and strategies used by enterprises for data analysis and business information.
* **History**: Early BI systems began in the 1960s as decision support systems (DSS). Evolved with OLAP and data warehousing in the 1980s–1990s.
* **Architecture & Components**:
  + Data sources (databases, files)
  + ETL (Extract, Transform, Load) tools
  + Data warehouse
  + OLAP tools
  + BI tools for visualization (e.g., Tableau)
* **Scenarios**: Sales forecasting, customer behavior analysis, inventory tracking, fraud detection.
* **Future & Goals**: Predictive and prescriptive analytics, real-time data processing, self-service BI.
* **Data, Information & Knowledge**:
  + *Data* is raw;
  + *Information* is processed data;
  + *Knowledge* is actionable understanding derived from information.
* **BI Tasks & Analysis Formats**: Dashboards, scorecards, ad-hoc queries, alerts.

**Decision Support Systems (DSS):**

* **Definition**: Computer-based systems that support complex decision-making and problem-solving.
* **Information Systems & Decision Making**: Role of MIS, DSS, and EIS in decision making.
* **Simon’s Decision-Making Process**:
  1. Intelligence (identifying problems)
  2. Design (developing solutions)
  3. Choice (selecting solution)
* **BI-DSS Connection**: DSS uses BI outputs to support managerial decisions.

📌 **Case Study**: Nationwide Insurance – used BI to improve customer service.

**Unit II: Modelling in Business Intelligence (6 Hours)**

**Modelling Concepts:**

* **Model Use in BI**: Represents real-world processes for analysis and prediction.
* **Model Presentation**: How a model is visualized or communicated (charts, diagrams).
* **Model Building & Assessment**:
  + Building includes defining variables and relationships.
  + Assessment includes accuracy, interpretability, performance.
* **Quality of Models**: Depends on accuracy, robustness, scalability.

**Modelling Techniques:**

* **Logical Structures**:
  + *Ontology*: Representation of knowledge as a set of concepts.
  + *Frame*: Structured format for representing data.
* **Graph Structures**:
  + *Business Process Model and Notation (BPMN)*: Flowcharts representing processes.
* **Probabilistic Structures**: Bayesian networks, Markov chains.
* **Analytical Structures**: Mathematical models for prediction or optimization.

**Model and Data:**

* **Data Generation**: From sensors, transactions, web logs.
* **Role of Time**: Temporal relevance of data.
* **Data Quality**: Accuracy, completeness, timeliness, consistency.

📌 **Case Study**: Use of ontologies in smart city BI modeling (Springer link).

**Unit III: Data Provisioning and Data Visualization (6 Hours)**

**Data Provisioning:**

* **Data Warehousing**: Central repository of integrated data.
* **Schemas**: Star, Snowflake schemas used to design data warehouses.
* **Data Quality & Profiling**: Validating data accuracy and consistency.
* **Data Enrichment & Duplication**: Enhancing data with external sources; removing redundancy.
* **ETL (Extract, Transform, Load)**:
  + *Extraction*: Retrieving data.
  + *Transformation*: Data cleaning, standardization.
  + *Loading*: Inserting into the target system.
* **Staging, Data Marts, Cubes**: Intermediate storage; subject-specific data stores; OLAP cubes.

**Data Visualization:**

* **Business Report**: Summarizes data insights.
* **Components**: Charts, KPIs, scorecards.
* **Types of Visualizations**: Bar, line, pie, scatter plots, heatmaps.
* **Visual Analytics**: Interactive data exploration.
* **Performance Dashboards**: Monitor KPIs.

**BI Tools:**

* Tableau, Power BI, Dundas BI, Oracle BI, Excel

📌 **Case Study**: Uber’s data-driven maps and dashboard visualization.

**Unit IV: Data Pre-processing Techniques (6 Hours)**

**Data Validation:**

* Handling **incomplete** or **noisy data** using imputation or smoothing.

**Data Transformation:**

* **Standardization**: Scaling values (z-score, min-max)
* **Feature Extraction**: Creating new variables
* **Dimensionality Reduction**:
  + *Sampling*
  + *Feature selection*
  + *Principal Component Analysis (PCA)*

**Data Discretization: Binning continuous variables.**

**Data Exploration:**

* **Univariate** (single variable):
  + Histograms, bar charts, boxplots
  + Mean, median, mode, range, variance
* **Bivariate** (two variables):
  + Scatterplots, correlation coefficients
  + Contingency tables for categorical data
* **Multivariate**:
  + Pairplots, correlation matrices

📌 **Case Study**: Data preparation in BI using ETL pipelines (Panoply blog).

**Unit V: Impact of Machine Learning in BI (6 Hours)**

**Regression:**

* Predicting numerical outcomes.
* Models: Simple linear, multiple regression.
* Metrics: RMSE, MAE, R².

**Classification:**

* Predicting categories.
* Algorithms: Logistic regression, Naive Bayes.
* Metrics: Accuracy, Precision, Recall, F1-score.

**Clustering:**

* Grouping similar data without labels.
* Techniques: K-means (partition), Agglomerative clustering (hierarchical).
* Evaluation: Silhouette score, Davies–Bouldin Index.

**Association Rule Mining:**

* Discovering relations between variables in large datasets.
* *Apriori Algorithm*: Commonly used for market basket analysis.
* Example: {bread} → {butter} with support/confidence.

📌 **Case Study**: Stock market analysis using ML tools.

**Unit VI: BI Applications, Emerging Trends and Future Impacts (6 Hours)**

**BI Applications:**

* **Education**: Student performance monitoring.
* **Healthcare**: Patient data analytics.
* **Logistics & SCM**: Inventory optimization.
* **CRM**: Customer segmentation, churn prediction.
* **Banking**: Fraud detection, credit scoring.
* **Telecom**: Usage pattern analysis.
* **Manufacturing**: Predictive maintenance.

**Emerging Trends:**

* **Location-Based Analytics**: GPS-based insights.
* **Mobile BI**: BI on smartphones, tablets.
* **Web 2.0 & Social Media**: Real-time data from platforms like Twitter.
* **Cloud BI**: Scalable, on-demand BI using cloud platforms (AWS, Azure).
* **Issues**:
  + Data privacy and security
  + Integration complexity
  + Real-time processing challenges