Nepal Engineering Council Registration Examination

Artificial Intelligence & Machine Learning Engineering Syllabus (AAIM)

Preamble: Chapters 1-4 cover fundamentals/principles of concepts in artificial intelligence and machine learning engineering; chapters 5-9 are related to the application of AI/ML engineering principles in practice; and the last (10th) chapter is related to project planning, design, and implementation.

(AAIM01)

1. Basic Electrical, Electronics and Computer Engineering Fundamentals

1.1 Core Electrical and Semiconductor Principles:

- **Semiconductor Devices:** PN Junction Diode (V-I Characteristics). BJT and MOSFET: operation as a switch.
- **Alternating Current Fundamentals:** Generation of Sinusoidal AC, RMS Value, Single Phase AC Circuits, Active Power, Introduction to Three-Phase Systems. **(AAIM0101)**

1.2 Digital Logic Foundations: Number Systems (Binary, Hexadecimal). Logic Gates (AND, OR, NOT, NAND, NOR, XOR). Boolean Algebra and Simplification. **(AAIM0102)**

1.3 Combinational and Sequential Circuits: Combinational Circuits: Adders, Multiplexers, Decoders; Sequential Circuits: Flip-Flops (SR, JK, D). Registers. **(AAIM0103)**

1.4 Fundamentals of Information Technology and Computer Systems: Database Management Systems (DBMS): Relational model and basic concepts.Software Development Life Cycle (SDLC) models. Version Control Systems. Fundamentals of Web Technologies (HTML, CSS, HTTP/S). **(AAIM0104)**

1.5 Fundamentals of Operating Systems and Networking: Operating Systems: Key functions (Process Management, Memory Management, File Systems); Computer Networks: Basic concepts of LAN, WAN, IP addressing, and essential network protocols (TCP/IP, HTTP/S); Introduction to network security principles. **(AAIM0105)**

1.6 Introduction to Computer Organization: Basic Von Neumann Architecture (CPU, Memory, I/O). Memory Hierarchy (Cache, RAM, Secondary Storage). I/O Interface (Programmed I/O, Interrupts). Introduction to the system bus. **(AAIM0106)**

(AAIM02)

2. Programming, Data Structures and Algorithms

2.1 Programming Fundamentals with Python: Data Types, Operators, Control Flow, Functions. Introduction to Python Libraries for AI/ML: NumPy, Pandas. **(AAIM0201)**

2.2 Object-Oriented Programming (OOP) Concepts: Classes, Objects, Inheritance, Polymorphism, Encapsulation, Abstraction. Implementing OOP in Python. **(AAIM0202)**

2.3 Data Structures and Algorithms: Arrays, Stacks, Queues, Linked Lists. Trees (Binary, BST). Graphs (Terminology, Representation). Time and Space Complexity (Big-O Notation). Searching (Linear, Binary, **Space Search**). Sorting (Bubble, Selection, Insertion, Merge, Quick). **(AAIM0203)**

2.4 Advanced Database Systems for AI/ML: Database design for ML pipelines and data warehousing. Working with non-relational (NoSQL) databases for unstructured data. Efficient SQL querying for large-scale data analysis and feature extraction. **(AAIM0204)**

2.5 Software Engineering Practices for AI Systems: Agile methodologies and CI/CD pipelines specifically for ML projects (MLOps). Code quality, testing, and debugging for machine learning models. Collaborative development using Git for AI research and deployment. **(AAIM0205)**

2.6 Operating Systems and Command Line Tools: Essential command line operations and shell scripting (using common shells like Bash; Process management and environment management. **(AAIM0206)**

(AAIM03)

3. Mathematical Foundations for AI & ML

3.1 Linear Algebra: Vectors, Matrices, Determinants. Eigenvalues and Eigenvectors. Singular Value Decomposition (SVD). **(AAIM0301)**

3.2 Calculus and Optimization: Derivatives, Partial Derivatives, Gradient, Jacobian, Hessian. Maxima, Minima, and Introduction to Convex Optimization. **(AAIM0302)**

3.3 Probability Theory: Basic Probability, Conditional Probability, Bayes' Theorem. Random Variables and Probability Distributions (Binomial, Gaussian, Poisson). **(AAIM0303)**

3.4 Statistics and Inference: Descriptive Statistics (Mean, Variance, Standard Deviation). Sampling, Estimation, Confidence Intervals, Hypothesis Testing, Correlation, and Regression. **(AAIM0304)**

3.5 Information Theory: Entropy, Cross-Entropy, Kullback-Leibler Divergence, and their applications in ML. **(AAIM0305)**

3.6 Numerical Methods: Algorithms for solving linear systems, numerical optimization (gradient descent), and computational complexity. **(AAIM0306)**

(AAIM04)

4. Core Artificial Intelligence

4.1 Introduction to AI and Intelligent Agents: Definition, History, Applications. Types of agents, structure of agents, and environments. **(AAIM0401)**

4.2 Problem Solving by Search: Uninformed search (BFS, DFS, DLS, IDS). Informed search (Greedy Best-First, A*). Local search algorithms. **(AAIM0402)**

4.3 Adversarial Search & Game Playing: Minimax algorithm, alpha-beta pruning, and evaluation functions. **(AAIM0403)**

4.4 Knowledge Representation & Reasoning: Propositional logic, **Predicate logic (First-Order Logic)**, inference, and forward/backward chaining. **Inference and Resolution. (AAIM0404)**

4.5 Automated Planning: STRIPS representation, partial-order planning, and hierarchical planning. **(AAIM0405)**

4.6 Reasoning under Uncertainty: Acting under uncertainty, basic probability models, Bayesian networks, and **Hidden Markov Models (HMM)**. **(AAIM0406)**

(AAIM05)

5. Foundations of Machine Learning

5.1 Introduction to ML: Types of learning (supervised, unsupervised, reinforcement), hypothesis space, inductive bias, and evaluation metrics. **(AAIM0501)**

5.2 Supervised Learning - Regression: Linear regression, polynomial regression, regularization techniques (Ridge, Lasso). **(AAIM0502)**

5.3 Supervised Learning - Classification: Logistic regression, k-Nearest Neighbors (k-NN), Naive Bayes classifier. **(AAIM0503)**

5.4 Advanced Supervised Learning: Support Vector Machines (SVMs), Decision Trees, and Ensemble Methods (Bagging, Random Forest, Boosting). **(AAIM0504)**

5.5 Unsupervised Learning: Clustering (k-means, hierarchical, DBSCAN). Dimensionality reduction (LDA, t-SNE). **(AAIM0505)**

5.6 Neural Networks & Fundamentals of Deep Learning: Perceptrons, multi-layer perceptrons, activation functions, loss functions, **Forward Propagation, and Backpropagation. (AAIM0506)**

(AAIM06)

6. Deep Learning and Advanced Models

6.1 Convolutional Neural Networks (CNNs): Architecture, layers (convolutional, pooling, fully connected), and applications in computer vision. **(AAIM0601)**

6.2 Recurrent Neural Networks (RNNs): Architecture, LSTM, GRU, and applications in sequence modeling and time series analysis. **(AAIM0602)**

6.3 Deep Learning Frameworks: Introduction to TensorFlow **or** PyTorch for building, training, and deploying deep learning models. **(AAIM0603)**

6.4 Autoencoders & Generative Models: Variational Autoencoders (VAEs) and Generative Adversarial Networks (GANs). **(AAIM0604)**

6.5 Deep Reinforcement Learning: Q-learning, policy gradients, Deep Q-Networks (DQN), and applications. **(AAIM0605)**

6.6 Optimization for Deep Learning: Adaptive learning rate methods (Adam, RMSprop), batch normalization, and regularization techniques (dropout). **(AAIM0606)**

(AAIM07)

7. Natural Language Processing and Computer Vision

7.1 NLP Fundamentals: Text preprocessing, tokenization, stemming, lemmatization, and n-grams. **(AAIM0701)**

7.2 Text Representation: Bag-of-words, TF-IDF, word embeddings (Word2Vec, GloVe), and contextual embeddings. **(AAIM0702)**

7.3 Language Modeling: N-gram models, neural language models, and perplexity. **(AAIM0703)**

7.4 Sequence-to-Sequence Models and Transformers: Encoder-decoder architecture, attention mechanisms, and the Transformer architecture (BERT, GPT). **(AAIM0704)**

7.5 Computer Vision Fundamentals: Image Processing: Color spaces, filtering, edge detection. Feature detection (SIFT, ORB). **(AAIM0705)**

7.6 Advanced Computer Vision: Object detection (R-CNN, YOLO, SSD). Image segmentation (U-Net, Mask R-CNN). Introduction to video analysis. **(AAIM0706)**

(AAIM08)

8. AI Systems Engineering and MLOps

8.1 Parallel and Distributed Systems for AI: Fundamentals of **parallel and distributed processing** for scalable AI system design. **(AAIM0801)**

8.2 MLOps Fundamentals: Continuous Integration/Continuous Deployment (CI/CD) for ML, model versioning, and reproducibility. **(AAIM0802)**

8.3 Data Pipeline Engineering: Data ingestion, validation, and creating efficient training pipelines (e.g., with TFX, Kubeflow). **(AAIM0803)**

8.4 Model Deployment & Serving: Packaging models, REST APIs, containerization (Docker), and serving on cloud/edge devices. **(AAIM0804)**

8.5 Monitoring & Maintenance: Model performance monitoring, data drift detection, and concept drift. **(AAIM0805)**

8.6 Cloud Platforms for AI: Overview of AI services on major cloud platforms (AWS, GCP, Azure). **(AAIM0806)**

(AAIM09)

9. Responsible AI and Advanced Applications

9.1 Ethics in AI: Bias, fairness, transparency, accountability, and ethical guidelines for AI development. **(AAIM0901)**

9.2 Explainable AI (XAI): Techniques for interpreting and explaining decisions made by ML models. **(AAIM0902)**

9.3 AI Privacy & Security: Federated learning, differential privacy, and adversarial attacks on ML systems. **(AAIM0903)**

9.4 AI Policy, Law & Society: National and international regulations (e.g., EU AI Act), societal impact, and responsible innovation. **(AAIM0904)**

9.5 Advanced Applications: AI in healthcare, finance, robotics, and other domain-specific applications. **(AAIM0905)**

9.6 Current Trends & Research: Exploration of cutting-edge research papers and emerging trends in AI/ML (e.g., Generative AI). **(AAIM0906)**

(AAIM10)

10. Project Planning, Design and Implementation

10.1 Engineering drawings and its concepts: Fundamentals of standard drawing sheets, dimensions, scale, line diagram, orthographic projection, isometric projection/view, pictorial views, and sectional drawing. **(AAIM1001)**

10.2 Engineering Economics: understanding of project cash flow; discount rate, interest and time value of money; basic methodologies for engineering economics analysis (Discounted Payback Period, NPV, IRR & MARR); comparison of alternatives, depreciation system and taxation system in Nepal. **(AAIM1002)**

10.3 Project planning and scheduling: project classifications; project life cycle phases; project planning process; project scheduling (bar chart, CPM, PERT); resources levelling and smoothing; monitoring/evaluation/controlling. **(AAIM1003)**

10.4 Project management: Information system; project risk analysis and management; project financing, tender and its process, and contract management. **(AAIM1004)**

10.5 Engineering professional practice: Environment and society; professional ethics; regulatory environment; contemporary issues/problems in engineering; occupational health and safety; roles/responsibilities of Nepal Engineers Association (NEA). **(AAIM1005)**

10.6 Engineering Regulatory Body: Nepal Engineering Council (Acts & Regulations). **(AAIM1006)**

Appendices

Appendix A: Table of Abbreviations

Abbreviation	Expansion
AC	Alternating Current
AI	Artificial Intelligence
ANN	Artificial Neural Network
API	Application Programming Interface
AR	Architecture and Organization
AWS	Amazon Web Services
Bayes' Thm	Bayes' Theorem
BFS	Breadth-First Search
BJT	Bipolar Junction Transistor
CNN	Convolutional Neural Network
CPU	Central Processing Unit
CI/CD	Continuous Integration / Continuous Deployment
DC	Direct Current
DNN	Deep Neural Network
DFS	Depth-First Search
FTP	File Transfer Protocol
GAN	Generative Adversarial Network
GCP	Google Cloud Platform

GPT	Generative Pre-trained Transformer
GPU	Graphics Processing Unit
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
I/O	Input/Output
IoT	Internet of Things
LSTM	Long Short-Term Memory
ML	Machine Learning
MLOps	Machine Learning Operations
MOSFET	Metal-Oxide-Semiconductor Field-Effect Transistor
NLP	Natural Language Processing
OOP	Object-Oriented Programming
OS	Operating System
PCA	Principal Component Analysis
PLC	Programmable Logic Controller
RAM	Random Access Memory
ReLU	Rectified Linear Unit
RNN	Recurrent Neural Network
ROM	Read-Only Memory
RMS	Root Mean Square
SQL	Structured Query Language
SVM	Support Vector Machine
SVD	Singular Value Decomposition
TF-IDF	Term Frequency-Inverse Document Frequency
VAE	Variational Autoencoder
VLSI	Very Large-Scale Integration
XAI	Explainable Artificial Intelligence