**Combined Roadmap: Generative AI, Data Structures & Algorithms, and System Design (16-Month Plan)**

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**1. Overview**

This 16-month roadmap is designed for learners aiming to master Generative AI, Data Structures & Algorithms (DSA), and System Design. The plan combines theoretical understanding with practical application, helping you build a strong portfolio and prepare for software engineering roles in product-based companies.

**2. Month-by-Month Plan**

|  |  |
| --- | --- |
| **Month** | **Focus** |
| 1-2 | Math Fundamentals + DSA Basics + Python |
| 3-4 | Core DSA + Object-Oriented Programming |
| 5-6 | Machine Learning + Intermediate DSA |
| 7-8 | Deep Learning + System Design Fundamentals |
| 9-10 | Generative AI + Advanced DSA |
| 11-12 | Tools, APIs, Deployment, and Vector DBs |
| 13-14 | System Design Advanced Topics + Projects |
| 15-16 | Final Portfolio, Resume, and Interview Prep |

**3. Phase 1: Foundations (Month 1-2)**

**3.1 Mathematics for AI (Total: ~30-40 hours)**

* Linear Algebra: Matrix operations, vector spaces, dot products, eigenvalues (3Blue1Brown)
* Calculus: Derivatives, gradients, chain rule, partial derivatives (Khan Academy)
* Probability and Statistics: Mean, variance, distributions, Bayes Theorem (Khan Academy)

**3.2 Python Programming (Total: ~30 hours)**

* Python basics: Variables, loops, functions, conditions
* Data structures: Lists, dictionaries, sets
* Libraries: Numpy (math), Pandas (data analysis), Matplotlib (visualization)
* Course: [Python for Everybody](https://www.coursera.org/specializations/python)

**3.3 DSA Basics (Total: ~40-50 hours)**

* Arrays, Strings, Linked Lists: Iteration, traversal, manipulation
* Stack, Queue, Recursion: Implementation and problem-solving
* Platform: [LeetCode Easy Track](https://leetcode.com/)

**4. Phase 2: Programming & Core DSA (Month 3-4)**

**4.1 Object-Oriented Programming (~15-20 hours)**

* Concepts: Classes, Objects, Inheritance, Encapsulation, Abstraction, Polymorphism
* Hands-on: Implement real-world scenarios using OOP
* Resource: [Automate the Boring Stuff](https://automatetheboringstuff.com/)

**4.2 Core DSA (~50-60 hours)**

* Hash Maps, Trees, Binary Trees: Implementation and traversal techniques
* Binary Search, Two Pointers, Sliding Window: Common patterns
* Graphs: BFS, DFS, adjacency list/matrix
* Practice on: [NeetCode 150](https://neetcode.io/)

**5. Phase 3: Machine Learning + DSA Intermediate (Month 5-6)**

**5.1 Machine Learning Basics (~40-50 hours)**

* Supervised: Linear/Logistic Regression, Decision Trees
* Unsupervised: Clustering (K-Means), Dimensionality Reduction (PCA)
* Tools: Scikit-Learn, Jupyter Notebook
* Courses: [Andrew Ng ML](https://www.coursera.org/learn/machine-learning), [Hands-On ML](https://www.oreilly.com/library/view/hands-on-machine-learning/9781492032632/)

**5.2 Intermediate DSA (~50-60 hours)**

* Recursion + Backtracking: Sudoku Solver, N-Queens
* Priority Queues/Heaps: Top-K problems
* Tries: Auto-completion, prefix searches
* Bit Manipulation, Intervals, Greedy algorithms
* Platform: [InterviewBit](https://www.interviewbit.com/)

**6. Phase 4: Deep Learning + System Design Basics (Month 7-8)**

**6.1 Deep Learning (~40-60 hours)**

* Neural Networks: Feedforward, activation functions
* CNNs: For image recognition (MNIST, CIFAR)
* RNNs, LSTMs: For sequential data, time series, NLP
* Projects: Digit classifier, sentiment analysis
* Courses: [Deep Learning Specialization](https://www.coursera.org/specializations/deep-learning), [Fast.ai](https://course.fast.ai/)

**6.2 System Design Basics (~30 hours)**

* Basics: Load balancers, stateless servers, caching
* Concepts: Scalability, High Availability, Latency vs Throughput
* Patterns: Monolith vs Microservices
* Resource: [System Design Primer GitHub](https://github.com/donnemartin/system-design-primer)

**7. Phase 5: Generative AI + Advanced DSA (Month 9-10)**

**7.1 NLP & Transformers (~40-50 hours)**

* NLP Foundations: Tokenization, stemming, embeddings
* Transformers: Self-attention, BERT, GPT models
* Courses: [Hugging Face NLP](https://huggingface.co/learn/nlp-course/), [The Illustrated Transformer](https://jalammar.github.io/illustrated-transformer/)

**7.2 GANs & Diffusion Models (~40 hours)**

* GANs: Generator/Discriminator, loss functions
* Diffusion: Stable Diffusion, image-to-text
* Courses: [GANs Specialization](https://www.coursera.org/specializations/generative-adversarial-networks-gans), [Diffusion Blog](https://lilianweng.github.io/lil-log/2021/07/11/diffusion-models.html)

**7.3 Advanced DSA (~60+ hours)**

* Dynamic Programming: Memoization, tabulation
* Graph Theory: Dijkstra, Floyd-Warshall, Union-Find
* Segment Trees, Disjoint Sets, Fenwick Trees
* Practice: [GFG Self-Paced DSA](https://practice.geeksforgeeks.org/)

**8. Phase 6: Tools, Frameworks, and APIs (Month 11-12)**

* Hugging Face: Tokenizer, pipeline, model loading [Docs](https://huggingface.co/docs)
* OpenAI API: Completion, Chat models, fine-tuning [Cookbook](https://github.com/openai/openai-cookbook)
* LangChain: RAG, tools, chains, memory [Docs](https://docs.langchain.com/)
* Track Experiments: [Weights & Biases](https://wandb.ai/site)
* Deployment: [Streamlit](https://docs.streamlit.io/), [Gradio](https://www.gradio.app/)
* Vector DBs: [FAISS](https://github.com/facebookresearch/faiss), [Pinecone](https://www.pinecone.io/), [Weaviate](https://weaviate.io/)

**9. Phase 7: System Design Advanced Topics (Month 13-14)**

* Distributed Systems, Load Sharding
* Queues: Kafka, RabbitMQ, Event-driven architecture
* Rate Limiting: Token bucket, Leaky bucket
* Caching: CDN, Redis, Memcached
* Scaling: Vertical vs Horizontal, Database replication
* Resource: [Grokking the System Design Interview](https://www.educative.io/courses/grokking-the-system-design-interview)

**10. Phase 8: LLM Projects + System Integration (Month 15)**

* Chatbot with LangChain + OpenAI
* PDF Query Bot (RAG with FAISS or Pinecone)
* Resume Analyzer using BERT
* Stable Diffusion Generator + Image Classifier
* Deploy full-stack Gen AI apps with APIs and vector DBs

**11. Phase 9: Final Portfolio + Mock Interviews (Month 16)**

* Finalize GitHub profile, README, code structure
* Host projects on Hugging Face/Streamlit
* Resume writing, STAR-based system design answers
* Practice mock DSA rounds on [LeetCode](https://leetcode.com/)
* Mock system design interviews with peers or [Pramp](https://www.pramp.com/)

**12. Additional Resources and Tools**

* [LeetCode](https://leetcode.com/)
* [GeeksForGeeks](https://practice.geeksforgeeks.org/)
* [HackerRank](https://www.hackerrank.com/skills-directory)
* [InterviewBit](https://www.interviewbit.com/)
* [System Design Primer](https://github.com/donnemartin/system-design-primer)
* [Awesome Generative AI](https://github.com/steven2358/awesome-generative-ai)
* [Buildspace](https://buildspace.so/)

**16-Month Breakdown**

* 16 months = ~480 days
* Target learning time = **700 hours**
* Average required = **1.5 hours/day**