Zero to Hero in Retrieval Augmented Generation

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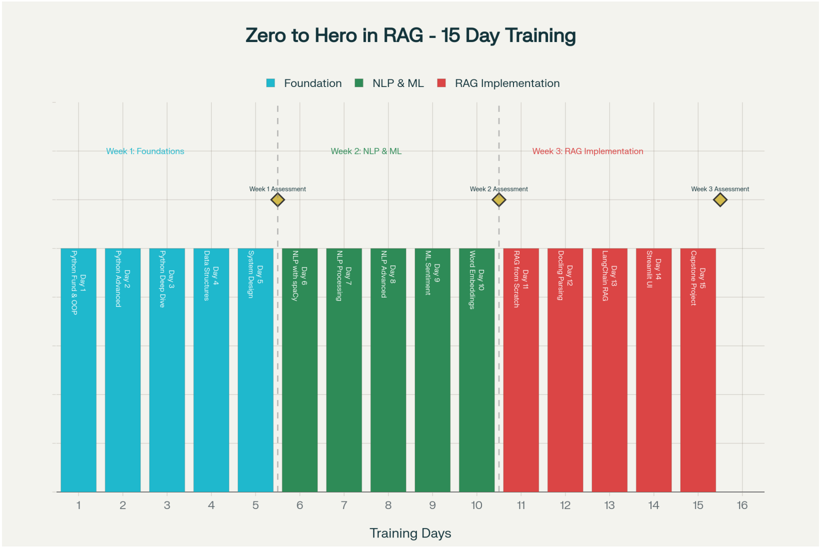
Program at a Glance



From Zero to Hero in RAG
Then from RAG to Riches

Learning Path: Python → DSA → System Design → NLP → RAG → Production

Program Overview

- Duration: 15 working days (3 weeks)
- Daily: 8 hours (4 learning + 4 coding)
- Target: Software engineers with basic programming knowledge

What You'll Build

- 15 progressive projects
- 1 production capstone
- Complete end-to-end RAG

Portfolio Highlights:

- Week 1: 5 Python projects + System design
- Week 2: NLP pipeline + Embeddings + Vector stores
- Week 3: Production RAG system with UI

Weekly Structure:

- Saturday (Pre-week): Online overview + QnA (2 hours)
- Monday-Friday: Daily learning + coding (8 hours)
- Final Saturday: Capstone review + QnA (4 hours)

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Program Architecture

Phase 1: Foundations (Days 1-5)

- Python Fundamentals
- File Handling
- Async Programming
- DSA Essentials
- System Design Basics

Phase 2: NLP & ML (Days 6-10)

- Text Processing
- NLP with spaCy
- Vectorization
- Sentiment Analysis
- Word Embeddings

Phase 3: RAG (Days 11-15)

- RAG from Scratch
- Docling Parsing
- LangChain RAG
- Streamlit UI
- Capstone Project

Daily Structure:

- 09:00-13:00: Learning (tutorials + documentation)
- 14:00-18:00: Coding (2 project options - pick 1)

Weekly Milestones:

- Pre-Week Saturday: Online overview session + QnA (2 hrs)
- End-Week Assessment: Project review + readiness check
- Final Saturday (Week 3): All capstone reviews + QnA (4 hrs)

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Day 1: Python Fundamentals & OOP

Morning Session (4 hrs)

- Variables & data types
- Control flow (if, loops)
- Functions & scope
- Object-oriented programming
- Classes & objects
- Inheritance & polymorphism

Afternoon: Pick 1 Project

- **Library Management:** Build a system with books, members, lending with OOP classes and inheritance
- **Shopping Cart System:** Create product catalog, cart operations, checkout with discount calculations using OOP

Learning Resources:

- Python Basics (https://www.freecodecamp.org/news/learn-python-basics/)
- Python OOP (https://www.freecodecamp.org/news/object-oriented-programming-python/)
- Documentation: Python Official Docs (https://docs.python.org/3/tutorial)

Difficulty: Medium |**Time:** 4 hours |**Deliverable:** Working code + README

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Day 2: Python File Handling & Decorators

Morning Session (4 hrs)

- File I/O operations
- Reading/writing text files
- JSON handling
- CSV processing
- Exception handling
- Decorators basics

Afternoon: Pick 1 Project

- **CSV Data Processor:** Read CSV files, filter/transform data, export results with error handling and logging decorator
- **Config File Manager:** Build JSON/YAML config reader/writer with validation, backup system using context managers

Learning Resources:

- File Handling (https://www.freecodecamp.org/news/file-handling-in-python/)
- Decorators (https://www.freecodecamp.org/news/python-decorators-explained-with-examples/)

Difficulty: Medium |**Time:** 4 hours |**Deliverable:** Working code + README

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Day 3: Python Advanced Deep Dive

Morning Session (4 hrs)

- List/dict/set comprehensions
- Generator expressions
- Async/await basics
- Asyncio fundamentals
- Concurrent operations
- Async file operations

Afternoon: Pick 1 Project

- **Async Web Scraper:** Fetch multiple URLs concurrently, parse HTML, save results using asyncio and aiohttp
- **Concurrent File Processor:** Process multiple large files in parallel with async I/O and progress tracking

Learning Resources:

- FreeCodeCamp: Concurrency vs. Parallelism (https://www.freecodecamp.org/news/concurrency-vs-parallelism-whats-the-difference-and-why-should-you-care/)
- Getting Started With Async Features in Python (https://realpython.com/python-async-features/)

Difficulty: Medium |**Time:** 4 hours |**Deliverable:** Working code + README

Day 4: Data Structures & Algorithms

Morning Session (4 hrs)

- Arrays & lists
- Hash tables/dictionaries
- Stacks & queues
- Binary search
- Sorting algorithms
- Big O complexity

Afternoon: Pick 1 Project

- **LeetCode Problem Set:** Solve 5 medium problems on arrays, hashmaps, and sorting with optimized solutions
- **Custom Data Structures:** Implement stack, queue, and hashmap from scratch with test cases and complexity analysis

Learning Resources:

- Learn Algorithms and Data Structures in Python (https://www.freecodecamp.org/news/algorithms-and-data-structures-free-treehouse-course/)
- Practice: LeetCode (https://leetcode.com/explore/learn/)

Difficulty: Medium |**Time:** 4 hours |**Deliverable:** Working code + README

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Day 5: System Design Fundamentals

Morning Session (4 hrs)

- Requirements analysis
- Scalability patterns
- Caching strategies
- Load balancing
- Database design
- API design

Afternoon: Pick 1 Project

- **URL Shortener:** Design and implement TinyURL-like service with hashing, database, and caching layer
- **API Rate Limiter:** Build token bucket/sliding window rate limiter with Redis-like cache and API endpoints

Learning Resources:

- System Design (https://www.freecodecamp.org/news/software-system-design-for-beginners/)
- System Design Interview Question https://www.freecodecamp.org/news/systems-design-for-interviews/
- Gaurav Sen System Design Youtube Playlist

Difficulty: Medium |**Time:** 4 hours |**Deliverable:** Design doc + Working code

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Week 1 Milestone Assessment

Learning Outcomes

- Python fundamentals mastery
- File & async operations
- DSA problem-solving
- System design thinking

Success Criteria

- 5 projects completed
- Code quality ¿80%
- Core concepts understood
- Ready for NLP phase

Assessment Activities:

- Code review of all 5 projects
- Technical Q&A on concepts
- System design explanation
- Readiness verification for Week 2

Assessment Rubric (100 pts):

- Functionality (50 pts) - All features working correctly
- Code Quality (20 pts) - Clean, documented, readable
- Design Principles (20 pts) - Architecture and patterns
- Documentation (10 pts) - README and comments

Day 6: Text Processing Fundamentals

Morning Session (4 hrs)

- Text preprocessing
- Tokenization
- Lowercasing & cleaning
- Stop word removal
- Stemming & lemmatization
- Regular expressions

Afternoon: Pick 1 Project

- **Text Preprocessing Pipeline:** Build modular pipeline for cleaning, tokenizing, and normalizing text data with configurable steps
- **Document Cleaner:** Create tool to extract clean text from messy documents with noise removal and format standardization

Learning Resources:

- NLP Tutorial (https://www.freecodecamp.org/news/natural-language-processing-techniques-for-beginners/)
- NLP using spaCy (https://www.freecodecamp.org/news/getting-started-with-nlp-using-spacy/)
- Documentation: Spacy Docs (https://spacy.io/usage/spacy-101)

Difficulty: Medium |**Time:** 4 hours |**Deliverable:** Working code + README

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Day 7: NLP with spaCy

Morning Session (4 hrs)

- spaCy pipeline basics
- Part-of-speech tagging
- Named Entity Recognition
- Dependency parsing
- Text similarity
- Pipeline customization

Afternoon: Pick 1 Project

- **Named Entity Extractor:** Build NER system to extract people, organizations, locations from documents with visualization
- **Text Similarity Engine:** Create document comparison tool using spaCy embeddings with ranking and scoring

Learning Resources:

- Natural Language Processing with spaCy (https://www.freecodecamp.org/news/natural-language-processing-with-spacy-python-full-course/)
- How to Extract Insights from Text (https://www.freecodecamp.org/news/extract-insights-from-text-using-named-entity-recognition/)

Difficulty: Medium |**Time:** 4 hours |**Deliverable:** Working code + README

Day 8: Text Vectorization

Morning Session (4 hrs)

- Bag of Words
- TF-IDF vectorization
- Feature extraction
- Cosine similarity
- Vector operations
- Scikit-learn vectorizers

Afternoon: Pick 1 Project

- **TF-IDF Search Engine:** Build keyword-based search using TF-IDF with document ranking and relevance scoring
- **Document Clusterer:** Create text clustering system using vectorization with visualization of document groups

Learning Resources:

- Understanding Word Embeddings (https://www.freecodecamp.org/news/understanding-word-embeddings-the-building-blocks-of-nlp-and-gpts/)
- How to process textual data using TF-IDF in Python (https://www.freecodecamp.org/news/how-to-process-textual-data-using-tf-idf-in-python-cd2bbc0a94a3/)

Difficulty: Medium |**Time:** 4 hours |**Deliverable:** Working code + README

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Day 9: Sentiment Analysis

Morning Session (4 hrs)

- Sentiment analysis basics
- Feature engineering
- ML classifiers (Naive Bayes, SVM)
- Model training & evaluation
- Cross-validation
- Model metrics

Afternoon: Pick 1 Project

- **Review Sentiment Analyzer:** Build classifier for product reviews with training pipeline and accuracy metrics
- **Tweet Sentiment Dashboard:** Create real-time sentiment analysis tool with classification and trend visualization

Learning Resources:

- What is Sentiment Analysis? (https://www.freecodecamp.org/news/what-is-sentiment-analysis-a-complete-guide-to-for-beginners/)
- Sentiment Analysis (https://www.freecodecamp.org/news/sentiment-analysis-with-text-mining/)
- Text Classification Demystified (https://www.freecodecamp.org/news/demystify-state-of-the-art-text-classification-word-embeddings/)
- A Deep Dive into Word Embeddings for Sentiment Analysis (https://www.freecodecamp.org/news/word-embeddings-for-sentiment-analysis/)

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Day 10: Word Embeddings

Morning Session (4 hrs)

- Word embeddings concepts
- Word2Vec (CBOW, Skip-Gram)
- Pre-trained embeddings
- Embedding similarity
- Sentence embeddings
- Vector databases basics

Afternoon: Pick 1 Project

- **Semantic Search Engine:** Build document search using embeddings with similarity ranking and query expansion
- **Word Analogy Solver:** Create tool for word analogies and relationships using pre-trained Word2Vec models

Learning Resources:

- Word Embeddings (https://www.freecodecamp.org/news/how-to-get-started-with-word2vec-and-then-how-to-make-it-work-d0a2fca9dad3/)
- Documentation: Gensim Word2Vec (https://radimrehurek.com/gensim/models/word2vec.html)

Difficulty: Medium |**Time:** 4 hours |**Deliverable:** Working code + README

Week 2 Milestone Assessment

Learning Outcomes

- Text processing mastery
- NLP pipeline creation
- ML classification skills
- Embeddings & similarity

Success Criteria

- 5 NLP projects completed
- ML model ¿75% accuracy
- Vector operations working
- Ready for RAG phase

Assessment Activities:

- NLP pipeline demonstration
- Sentiment model evaluation
- Embedding system walkthrough
- Component integration check

Assessment Rubric (100 pts):

- Functionality (50 pts) - All NLP components working
- Model Quality (20 pts) - Accuracy and performance
- Code Quality (20 pts) - Clean and documented
- Integration (10 pts) - Components work together

Day 11: RAG from Scratch

Morning Session (4 hrs)

- RAG architecture overview
- Document chunking strategies
- Vector stores (FAISS/ChromaDB)
- Retrieval mechanisms
- Re-ranking techniques
- Basic RAG pipeline

Afternoon: Pick 1 Project

- **Basic RAG System:** Build end-to-end RAG with document loading, chunking, embedding, retrieval, and generation
- **Multi-Document RAG:** Create RAG system handling multiple documents with metadata filtering and source attribution

Learning Resources:

- RAG Handbook (https://www.freecodecamp.org/news/retrieval-augmented-generation-rag-handbook/)
- LangChain RAG (https://www.freecodecamp.org/news/mastering-rag-from-scratch/)
- YouTube: "Complete RAG Crash Course With Langchain In 2 Hours" - Krish Naik

Key Pipeline: Load → Chunk → Embed → Store → Retrieve → Generate
Difficulty: Medium |**Time:** 4 hours |**Deliverable:** Working RAG + README

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Day 12: Document Parsing with Docling

Morning Session (4 hrs)

- Docling architecture
- PDF/DOCX/PPTX parsing
- Layout analysis
- Table extraction
- Image extraction
- Metadata handling

Afternoon: Pick 1 Project

- **Multi-Format Parser:** Build document parser supporting PDF/DOCX/PPTX with text, tables, and image extraction
- **Structured Data Extractor:** Create tool to extract hierarchical content with headings, sections, and metadata preservation

Learning Resources:

- Docling: A Step-by-Step Guide (https://www.datacamp.com/tutorial/docling)
- Documentation: Docling Official Docs (https://docling-project.github.io/docling/getting_started/)

Difficulty: Medium |**Time:** 4 hours |**Deliverable:** Working parser + README

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Day 13: LangChain RAG Implementation

Morning Session (4 hrs)

- LangChain Essentials course
- Document loaders
- Text splitters
- Embeddings integration
- Vector stores
- Retrieval chains
- LCEL expressions

Afternoon: Pick 1 Project

- **PDF Q&A System:** Build LangChain-based RAG for PDF documents with chat history and source citations
- **Conversational RAG:** Create multi-turn RAG chatbot with memory, context awareness, and follow-up questions

Learning Resources:

- Course: LangChain Academy Essentials (https://academy.langchain.com/courses/langchain-essentials-python)
- What is Retrieval Augmented Generation (RAG)? (https://www.datacamp.com/blog/what-is-retrieval-augmented-generation-rag)

Difficulty: Medium |**Time:** 4 hours |**Deliverable:** Working RAG + README

Day 14: Streamlit UI Development

Morning Session (4 hrs)

- Streamlit basics
- Layout components
- Interactive widgets
- File uploads
- Session state management
- Chat interfaces

Afternoon: Pick 1 Project

- **RAG Chatbot Interface:** Create interactive chat UI with file upload, message history, and streaming responses
- **Document Q&A Dashboard:** Build multi-page app with document upload, processing status, and query interface

Learning Resources:

- Streamlit (Build 12 Data Science Apps with Python and Streamlit)
- Documentation: Streamlit Official Docs (https://docs.streamlit.io/)

Difficulty: Medium |**Time:** 4 hours |**Deliverable:** Working UI + README

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Day 15: End-to-End Capstone Project

Morning Session (4 hrs)

- Architecture planning
- Component integration
- Testing strategies
- Performance optimization
- Error handling
- Deployment preparation

Pick 1 Full-Stack Project

- **Document Intelligence System:** Multi-format parser + RAG + chat UI with source attribution and metadata
- **Enterprise Knowledge Base:** Multi-document RAG with advanced search, filters, and analytics dashboard

Integration Requirements:

- Docling: Multi-format document parsing (PDF/DOCX/PPTX)
- LangChain: Complete RAG orchestration with chains
- Streamlit: Professional interactive web interface
- All components seamlessly integrated

Capstone Evaluation (100 pts): Functionality (40) |Code Quality (30) |Architecture (20) |Documentation (10)
Minimum Passing Score: 70/100

Week 3 Milestone & Final Assessment

Learning Outcomes

- Complete RAG systems
- Document processing mastery
- LLM orchestration
- Production-ready apps

Success Criteria

- Capstone fully functional
- All components integrated
- Code well-documented
- Production-ready quality

Production Readiness Checklist:

- Error handling & validation implemented
- Performance optimized (chunking, caching)
- Comprehensive documentation
- User-friendly interface
- Code quality ¿80%

Final Assessment Activities:

- Individual capstone project demonstrations (20 mins each)
- Architecture & design explanation
- Live code walkthrough
- Q&A on technical decisions
- Future enhancements discussion

Final Saturday: Capstone Reviews & QnA

Session Structure (4 hours):

- 10:00-12:30: Individual capstone presentations (20 mins each)
- 12:30-13:00: Break
- 13:00-14:00: Open QnA & technical discussions

Presentation Format (20 mins):

- Project demo (8 mins) - Live demonstration
- Architecture overview (5 mins) - System design & components
- Code walkthrough (5 mins) - Key implementation details
- Q&A (2 mins) - Questions from instructors

Evaluation Criteria:

- **Functionality (40 pts):** All features working, error-free
- **Code Quality (30 pts):** Clean, modular, documented
- **Architecture (20 pts):** Sound design, scalable structure
- **Documentation (10 pts):** Clear README, setup instructions

QnA Topics:

- Technical challenges faced & solutions
- RAG optimization techniques
- [illegible]

Congratulations! From RAG to Riches

Technical Skills Acquired

- Advanced Python programming
- NLP & text processing
- RAG architecture & implementation
- Full-stack AI development
- Production deployment

Career Pathways

- AI/ML Engineer
- RAG Solutions Architect
- LLM Application Developer
- AI Product Engineer
- NLP Engineer

Recommended Certifications:

- LangChain Academy Certification (academy.langchain.com)
- Azure AI Fundamentals (AI-900)
- AWS Machine Learning Specialty

Continuous Learning Resources:

- LangChain Academy (academy.langchain.com)
- DeepLearning.AI Short Courses (deeplearning.ai)
- Hugging Face NLP Course (huggingface.co/learn/nlp-course)
- LangChain Documentation (python.langchain.com)
- Explore open-source RAG projects on GitHub

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Weekly Saturday Sessions Schedule

Pre-Week Saturday Sessions (2 hours each):

Saturday Week 0 (Before Day 1):

- Program overview & expectations
- Week 1 preview: Python fundamentals to system design
- Development environment setup
- QnA session

Saturday Week 1 (Before Day 6):

- Week 1 recap & learnings
- Week 2 preview: NLP & ML foundations
- Introduction to text processing and embeddings
- QnA session

Saturday Week 2 (Before Day 11):

- Week 2 recap & portfolio review
- Week 3 preview: RAG systems & production
- RAG architecture deep dive
- QnA session

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Final Saturday (After Day 15):