

# Zero to Hero in RAG

## Intensive Training Program in Retrieval Augmented Generation

### From Zero to Hero in RAG

*Then from RAG to Riches*

**Learning Path:** Python → DSA → System Design → NLP  
→ ML → LLMs → RAG → Production

#### Full-Time Mode

- Duration: 15 working days (3 weeks)
- Daily: 8 hours (4 learning + 4 coding)
- Week 4: Independent capstone
- Saturdays: Overview + QnA (2 hrs)

#### Part-Time Mode

- Duration: 12 weeks (3 months)
- Weekly: Self-paced tutorials + coding
- Month 4: Independent capstone
- Weekends: Optional QnA sessions

#### What You'll Build:

- 12-15 progressive projects (choose 1 per day/week)
- 1 production-ready capstone system
- Complete end-to-end RAG portfolio

**Target Audience:** Software engineers with basic programming knowledge

### Program Architecture

#### Phase 1: Python Foundations (Days 1-5; Weeks 1-4)

- Python Fundamentals
- Data Science & ML Tools
- Async & Visualization
- DSA Essentials
- System Design (Optional)

#### Phase 2: NLP & ML (Days 6-10; Weeks 5-8)

- NLP with spaCy
- Machine Learning
- Word Embeddings
- LLMs & Prompting
- Transformers (Optional)

#### Phase 3: RAG (Days 11-15 Weeks 9-12)

- RAG from Scratch
- Docstring Parsing
- LangChain RAG

- Streamlit UI
- Cloud Deploy (Optional)

#### Daily/Weekly Structure:

- **Full-Time:** 09:00-13:00 Learning — 14:00-18:00 Coding (2 project options - pick 1)
- **Part-Time:** Self-paced tutorials + hands-on — Complete at your own pace

#### Milestones:

- End of each phase: Project review + readiness assessment
- Week/Month 4th: Independent capstone development
- Final Presentation: Capstone demos + QnA (4 hrs)

### Day 1; Week 1: Python Fundamentals

#### Learning Topics (4 hrs)

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

#### Project: Pick 1 (4 hrs)

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

### Day 2; Week 2: Data Science & ML Tools

#### Learning Topics (4 hrs)

- File I/O operations
- Pandas: DataFrames, data manipulation
- NumPy: Arrays, vectorization
- Hugging Face Transformers basics
- Flask: Web API fundamentals
- REST API creation

#### Project: Pick 1 (4 hrs)

- **Data Analysis API:** Build Flask API for CSV processing with Pandas, NumPy analytics endpoints
- **Text Analysis Service:** Create Flask API using Hugging Face models for sentiment/classification

#### Learning Resources:

- Pandas Tutorial (<https://www.freecodecamp.org/news/learn-pandas-for-data-science/>)
- NumPy Course (<https://www.freecodecamp.org/news/numpy-crash-course/>)
- Hugging Face Transformers (<https://huggingface.co/docs/transformers>)
- Flask Tutorial (<https://www.freecodecamp.org/news/how-to-build-a-web-app-using-pythons-flask/>)

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

### Day 3; Week 3: Async & Visualization Tools

#### Learning Topics (4 hrs)

- Async/await with asyncio
- Concurrent web scraping
- Matplotlib: Plots and visualizations
- BeautifulSoup: HTML parsing
- OpenCV: Image processing basics
- Computer vision fundamentals

#### Project: Pick 1 (4 hrs)

- **Web Scraper & Visualizer:** Async scraper with BeautifulSoup, data visualization with Matplotlib
- **Image Analysis Pipeline:** Build OpenCV pipeline for image processing with visual analytics dashboard

#### Learning Resources:

- Asyncio Tutorial (<https://realpython.com/python-async-features/>)
- Matplotlib Course (<https://www.freecodecamp.org/news/matplotlib-course-learn-python-data-visualization/>)
- BeautifulSoup Tutorial (<https://www.freecodecamp.org/news/web-scraping-python-tutorial-how-to-scrape-data-from-a-website/>)
- OpenCV Course (<https://www.freecodecamp.org/news/opencv-full-course/>)

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

## Day 4; Week 4: Data Structs & Algorithms

### Learning Topics (4 hrs)

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

### Project: Pick 1 (4 hrs)

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

### Learning Resources:

- Algorithms and Data Structures (<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

## Day 5: System Design Fundamentals

### Learning Topics (4 hrs)

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

### Project: Pick 1 (4 hrs)

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

### Learning Resources:

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

**Note:** Included in full-time Day 5 — Optional self-study for part-time learners

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

## Phase 1 Milestone Assessment

### Learning Outcomes

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

### Success Criteria

- 4-5 projects completed
- Code quality >80%
- Core concepts understood
- Ready for NLP phase

### Assessment Activities:

- Code review of all projects
- Technical Q&A on concepts
- Readiness verification for Phase 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; Week 5: NLP with spaCy

### Learning Topics (4 hrs)

- spaCy pipeline basics
- Text preprocessing & tokenization
- Part-of-speech tagging
- Named Entity Recognition (NER)
- Dependency parsing
- Pipeline customization

### Project: Pick 1 (4 hrs)

- **Named Entity Extractor:** Build NER system to extract entities from documents with visualization
- **Document Analysis Pipeline:** Create custom spaCy pipeline for text analysis with multiple components

### Learning Resources:

- NLP with spaCy (<https://www.freecodecamp.org/news/natural-language-processing-with-spacy-python-full-course/>)
- Extract Insights from Text (<https://www.freecodecamp.org/news/extract-insights-from-text-using-named-entity-recognition/>)
- Documentation: spaCy Docs (<https://spacy.io/usage/spacy-101>)

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

## Day 7; Week 6: Machine Learning

### Learning Topics (4 hrs)

- Types of Machine Learning
- Classification algorithms
- Clustering techniques
- Scikit-learn essentials
- Model training & evaluation
- Cross-validation & metrics

### Project: Pick 1 (4 hrs)

- **Text Classifier:** Build sentiment analysis or spam detection classifier with scikit-learn
- **Document Clusterer:** Create text clustering system with K-means and visualization

### Learning Resources:

- Machine Learning in Python (<https://www.freecodecamp.org/news/machine-learning-with-python-for-beginners/>)

- Scikit-Learn Course (<https://www.freecodecamp.org/news/scikit-learn-crash-course/>)
- Sentiment Analysis Tutorial (<https://www.freecodecamp.org/news/sentiment-analysis-with-text-mining/>)

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

## Day 8; Week 7: Word Embeddings

### Learning Topics (4 hrs)

- Bag of Words & TF-IDF
- Word embeddings concepts
- Word2Vec (CBOW, Skip-Gram)
- GloVe embeddings
- Similarity measures
- Vector operations

### Project: Pick 1 (4 hrs)

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

### Learning Resources:

- Understanding Word Embeddings (<https://www.freecodecamp.org/news/understanding-word-embeddings-the-building-blocks-of-nlp-and-gpts/>)
- Word2Vec Tutorial (<https://www.freecodecamp.org/news/how-to-get-started-with-word2vec-and-then-how-to-make-it-work-d0a2fcfa9dad3/>)
- 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

## Day 9; Week 8: Large Language Models & Prompt Engineering

### Learning Topics (4 hrs)

- Introduction to LLMs
- OpenAI API & models
- Prompt engineering basics
- Few-shot learning
- Prompt templates
- Best practices & safety

### Project: Pick 1 (4 hrs)

- **AI Writing Assistant:** Build text generation tool with prompt templates and OpenAI API
- **Intelligent Q&A Bot:** Create chatbot with context-aware prompts and conversation memory

### Learning Resources:

- ChatGPT Prompt Engineering (<https://www.freecodecamp.org/news/prompt-engineering-chatgpt-course/>)
- OpenAI API Tutorial (<https://www.freecodecamp.org/news/how-to-use-the-openai-api-to-build-apps/>)
- LLM Handbook (<https://www.freecodecamp.org/news/large-language-models-explained/>)

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

## Day 10: Transformers

### Learning Topics (4 hrs)

- Transformer architecture
- Attention mechanism
- BERT, GPT models
- Hugging Face ecosystem
- Transfer learning
- Fine-tuning basics

### Project: Pick 1 (4 hrs)

- **Transformer Classifier:** Fine-tune pre-trained BERT for text classification task
- **Custom Text Generator:** Fine-tune GPT-2 on custom dataset for domain-specific generation

### Learning Resources:

- Transformers Explained (<https://www.freecodecamp.org/news/transformer-neural-network-explained/>)
- Hugging Face Course (<https://www.freecodecamp.org/news/get-started-with-hugging-face/>)
- Fine-Tuning Tutorial (<https://www.freecodecamp.org/news/how-to-fine-tune-langs/>)

**Note:** Included in full-time Day 10 — Optional self-study for part-time learners

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

## Phase 2 Milestone Assessment

### Learning Outcomes

- NLP with spaCy mastery
- ML classification skills
- Word embeddings understanding
- LLM & prompting expertise

### Success Criteria

- 4-5 NLP projects completed
- ML model ≥ 75% accuracy
- Vector operations working
- Ready for RAG phase

### Assessment Activities:

- NLP pipeline demonstration
- Sentiment model evaluation
- 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; Week 9: RAG from Scratch

### Learning Topics (4 hrs)

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

### Project: Pick 1 (4 hrs)

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

### 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” - Krish Naik

**Key Pipeline:** Load → Chunk → Embed → Store → Retrieve → Generate

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

## Day 12; Week 10: Document Parsing with Docling

### Learning Topics (4 hrs)

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

### Project: Pick 1 (4 hrs)

- **Multi-Format Parser:** Build parser supporting PDF/DOCX/PPTX with text, tables, images
- **Structured Data Extractor:** Create tool for hierarchical content extraction

### Learning Resources:

- Docling: 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

## Day 13; Week 11: LangChain RAG Implementation

### Learning Topics (4 hrs)

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

### Project: Pick 1 (4 hrs)

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

### Learning Resources:

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

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

## Day 14; Week 12: Streamlit UI Development

### Learning Topics (4 hrs)

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

### Project: Pick 1 (4 hrs)

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

### Learning Resources:

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

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

## Day 15: Cloud Deployment

### Learning Topics (4 hrs)

- Cloud RAG architecture patterns
- AWS Bedrock: Foundation models & Knowledge Bases
- Azure AI Search & OpenAI integration
- Serverless deployment strategies
- Managed vector stores
- Cost optimization & scaling

### Project: Pick 1 (4 hrs)

- **AWS Bedrock RAG:** Deploy RAG using Bedrock Knowledge Bases, S3, Lambda
- **Azure AI RAG:** Build RAG with Azure AI Search, OpenAI, Blob Storage

### Learning Resources:

- AWS Bedrock Tutorial (<https://www.freecodecamp.org/news/how-to-use-amazon-bedrock-to-build-generative-ai-applications/>)
- Build AI Apps with Azure (<https://www.freecodecamp.org/news/build-ai-apps-with-azure-openai-and-semantic-kernel-sdk/>)
- AWS Docs: Bedrock Knowledge Bases (<https://docs.aws.amazon.com/bedrock/>)

**Note:** Included in full-time Day 15 — Optional self-study for part-time learners

**Cloud Integration:** Storage → Ingestion → Vector Store → LLM → API

**Difficulty:** Advanced |**Time:** 4 hours |**Deliverable:** Deployed RAG + Docs

## Phase 3 Milestone & Capstone Kickoff

### Learning Outcomes

- Complete RAG systems
- Document processing mastery
- LLM orchestration
- Cloud deployment (optional)

### Success Criteria

- All components working
- Code well-documented
- Ready for capstone

### Production Readiness Checklist:

- Local RAG implementation complete
- Error handling & validation implemented
- Performance optimized
- Comprehensive documentation

### Capstone Preview:

- Week/Month 4: Independent capstone development
- Build Document Intelligence System OR Enterprise Knowledge Base
- Integrate: Docling + LangChain + Streamlit + (optional) Cloud
- Prepare for final presentation

## Week/Month 4: Capstone Project

### Choose 1 Capstone Project:

- **Document Intelligence System:** Multi-format parser (Docing) + RAG + Streamlit UI + (optional) Cloud deployment
- **Enterprise Knowledge Base:** Multi-document RAG with advanced search, filters, analytics dashboard

### Integration Requirements:

- Docing: Multi-format document parsing (PDF/-DOCX/PPTX)
- LangChain: Complete RAG orchestration with chains
- Streamlit: Professional interactive web interface
- Cloud: AWS Bedrock OR Azure AI (optional but recommended)
- All components seamlessly integrated

### Development Schedule:

- **Full-Time:** Week 4 independent development with async mentor support
- **Part-Time:** Month 4 self-paced development with optional check-ins
- Daily/weekly progress tracking available
- Code review sessions on request

**Capstone Evaluation (100 pts):** Functionality (40) | Code Quality (30) | Architecture (20) | Documentation (10)

**Minimum Passing Score:** 70/100

## Capstone Presentation Day

### Session Structure (4 hours):

- 10:00-12:30: Individual capstone presentations (20 mins each)
- 12:30-13:00: Break
- 13:00-14:00: Open Q&A & 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

### Q&A Topics:

- Technical challenges & solutions
- RAG optimization techniques
- Production deployment considerations
- Career pathways & next steps

## Congratulations! From RAG to Riches

### Technical Skills Acquired

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

### Career Pathways

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

### Recommended Certifications:

- LangChain Academy Certification ([academy.langchain.com](https://academy.langchain.com))
- Azure AI Fundamentals (AI-900)
- AWS Machine Learning Specialty

### Continuous Learning Resources:

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

### Your Journey: Zero to Hero to Riches!

*Keep Building, Keep Learning, Keep Shipping!*