KOENIG SOLUTIONS · COURSE OUTLINE

# Calculus for AI: Gradient Descent & Backpropagation

Learn to apply derivatives, integrals and multivariable calculus to gradient descent, backpropagation and other AI optimisation techniques.

| 3 Days | 8 | 32 |
|---|---|---|
| 24 HOURS | MODULES | TOPICS |

## COURSE OVERVIEW

This course will empower participants with the mathematical tools necessary to tackle complex challenges in AI, ensuring they can apply calculus concepts confidently and effectively in their work.

## WHO THIS COURSE IS FOR

- AI Engineers
- Machine Learning Engineers
- Data Scientists
- AI Researchers
- Deep Learning Practitioners

## LEARNING OBJECTIVES

By the end of this course, participants will be able to:

- Apply Calculus in AI Contexts: Understand and utilize key calculus concepts such as derivatives, integrals, and multivariable calculus in the development and optimization of AI models
- Optimize Machine Learning Models: Apply differentiation techniques to optimize cost functions and understand gradient descent, backpropagation, and other key algorithms in AI
- Solve AI-Related Problems Using Integrals: Employ integration techniques to solve problems related to probability distributions, expectation, variance, and cumulative functions in AI
- Analyze Multivariable Functions: Work with multivariable calculus to compute gradients, divergences, and solve multiple integrals, enhancing the understanding and application of complex AI models
- Utilize Advanced Calculus Concepts: Apply higher-order derivatives, Taylor series, and differential equations to model time-dependent systems and dynamic behaviors in AI
- Bridge Theory and Practice: Translate theoretical calculus concepts into practical problem-solving skills directly applicable to AI tasks, fostering a deeper understanding of how calculus underpins AI technologies

### TRAINING APPROACH

The course is heavily focused on problem-solving, with minimal theory review. Each module is designed to provide practical application scenarios in AI.

COURSE SYLLABUS

# 8 Modules, 32 Topics

## DAY 1 Fundamentals of Calculus and Derivatives

### 01

2 hours

### Quick Review of Key Concepts

**LIMITS AND CONTINUITY**

- Brief review of limits, continuity, and their significance in calculus
- Practice problems on evaluating limits

**DIFFERENTIATION BASICS**

- Introduction to derivatives, the power rule, product rule, quotient rule, and chain rule
- Solving basic differentiation problems

### 02

3 hours

### Applications of Derivatives in AI

**OPTIMIZATION IN MACHINE LEARNING**

- Concept of gradient and its role in optimization
- Practice problems on finding local maxima and minima
- **Gradient Descent:** Understanding the algorithm through problem-solving

**BACKPROPAGATION IN NEURAL NETWORKS**

- Role of calculus in backpropagation
- Practical problems related to partial derivatives and their applications in adjusting weights

### 03

3 hours

### Higher-Order Derivatives

**SECOND AND HIGHER-ORDER DERIVATIVES**

- Understanding concavity, convexity, and points of inflection
- Practice problems on concavity, convexity, and their relevance in machine learning models

**TAYLOR SERIES EXPANSION**

- Application in approximating functions and understanding model behaviour
- Problems focused on series expansion in the context of AI algorithms

## DAY 2 Integrals and Their Applications

### 04

2 hours

### Basics of Integration

**INDEFINITE AND DEFINITE INTEGRALS**

- **Introduction to integration techniques:** substitution, integration by parts
- Practice problems focusing on indefinite and definite integrals

**APPLICATION OF INTEGRATION IN AI**

- Concept of area under the curve and its relevance in probability distributions and cost functions

### 05

3 hours

### Probability and Statistics in AI

**CUMULATIVE DISTRIBUTION FUNCTION (CDF) AND PROBABILITY DENSITY FUNCTION (PDF)**

- Role of integration in understanding probability distributions
- Practice problems focused on calculating areas under PDFs and working with CDFs

**EXPECTATION AND VARIANCE**

- Calculating expectation and variance using integrals
- Practical problems on computing moments and their application in statistical models

### 06

3 hours

### Multivariable Calculus and AI Applications

**MULTIPLE INTEGRALS**

- Double and triple integrals, with a focus on their applications in AI (e.g., volume under surfaces, joint probability distributions)
- Practice problems involving multiple integrals and their application in AI algorithms

**GRADIENT, DIVERGENCE, AND CURL**

- Introduction to vector calculus and its relevance in machine learning
- Practical problems to solidify understanding of these concepts

## DAY 3 Advanced Calculus Topics and AI Integration (Optional)

07

4 hours

### Differential Equations and Dynamical Systems

**ORDINARY DIFFERENTIAL EQUATIONS (ODES)**

- Introduction to ODEs and their role in AI (e.g., in modelling time-dependent systems)
- Practice problems focused on solving ODEs using separation of variables and integrating factors

**PARTIAL DIFFERENTIAL EQUATIONS (PDES)**

- Introduction to PDEs with examples from AI applications (e.g., heat equation in neural networks)
- Solving basic PDEs using separation of variables and Fourier series

08

4 hours

### Calculus of Variations and AI

**INTRODUCTION TO CALCULUS OF VARIATIONS**

- Application in optimizing functional, relevant in deep learning
- Practice problems on Euler-Lagrange equations

**APPLICATION IN AI AND DEEP LEARNING**

- Understanding the variational approach in AI models
- Solving problems that link calculus of variations with AI, such as deriving equations used in advanced AI models

WHAT IS INCLUDED

## Everything You Need to Succeed

- Koenig course material for every module
- Delivery by certified instructors and subject matter experts
- Hands-on exercises throughout the course
- Course completion certificate from Koenig

ABOUT KOENIG

## Who We Are

Established in 1993, Koenig Solutions is a globally recognised training provider with 35+ technology partnerships, 5,000+ training programmes and a network of certified instructors and subject matter experts, supporting individuals and enterprise teams worldwide.

FLEXIBLE DELIVERY

## Learn the Way That Suits You

Classroom Training | Live Online Classes (ILO) | Fly-Me-A-Trainer (FMAT) | Flexi (Self-Paced) | 1-on-1 Training

### Ready to Get Started?

Talk to a learning advisor about schedules, group training and customised delivery.

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