

AMCS 394C Contemporary Topics in Applied Math  
Mathematical Introduction to Deep Learning

## Course Information

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## Mathematical Introduction to Deep Learning

AMCS 394C, Spring 2023

Monday & Thursday: 9:30am-10:55am

Time: January 22 - May 17, 2023

Lecture Videos and Notes

Available in KAUST Blackboard System

Office Hours

Monday & Thursday: 11:00am-12:00pm (B1, L0, 0102)

or by Appointment

# Course Instructor and Assistants

- Instructor: Professor Jinchao Xu
- Email: [jinchao.xu@kaust.edu.sa](mailto:jinchao.xu@kaust.edu.sa)
- Teaching Assistants:
  - ▶ Dr. Juncai He ([juncai.he@kaust.edu.sa](mailto:juncai.he@kaust.edu.sa))
  - ▶ Dr. Boqian Shen ([boqian.shen@kaust.edu.sa](mailto:boqian.shen@kaust.edu.sa))
  - ▶ Dr. Xinliang Liu ([xinliang.liu@kaust.edu.sa](mailto:xinliang.liu@kaust.edu.sa))

# Course Description

- Lecture and Programming:
  - ▶ lectures providing motivations, description and mathematical analysis of deep learning algorithms
  - ▶ hands-on programming exercises for deep learning algorithms
- Course materials:
  - ▶ typed lecture notes
  - ▶ slides
  - ▶ recorded video lectures
  - ▶ related research papers
  - ▶ programming subroutines
- For interested and qualified students
  - ▶ research opportunities

# Course Description and Syllabus

Main topics include:

- Basics of machine learning and probability
- Logistic regression and support vector machine
- Gradient descent method and training algorithms
- Polynomial approximation and Weierstrass theorem
- Linear finite element spaces
- Deep neural networks and mathematical properties
- Convolutional neural networks
- Multigrid methods and MgNet
- Transformer and other architecture
- PyTorch and deep learning for image classification
- Other applications

# Policies

## Grading policies:

- ➊ Homework and programming assignments (collecting every one week) (40%)
- ➋ Projects and exams:
  - ▶ midterm exam (20%)
  - ▶ final exam (20%)
  - ▶ final project (20%)

## Course policies:

- **Attendance is mandatory.**
- **No late homework will be accepted.**
- Please pay attention to the due date of the assignments.
- Students should notify the instructor in advance of missing any class or as soon as possible thereafter.

# Prerequisites, References and Resources

## Prerequisites

- Multi-variable calculus;
- Linear algebra;
- Basic knowledge of numerical analysis;
- Some programming experiences with Python.

## References and resources:

- Xu J. Deep Learning and Analysis, Lecture Notes (to be published by Springer), 2023.
- Goodfellow I, Bengio Y, Courville A. Deep learning. MIT press, 2016.