Deep Learning

From Fundamentals to Research-Driven

Equipping You with Research Depth and
Industry Skills

By:

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Design this Course

Industry is not short of developers, it is short of thinkers

This course aims to:

- Build **problem formulation skills**

- Develop **experimental thinking**

- Train students to:

  - Read research papers

  - Implement published models

  - Modify architectures

  - Analyze results scientifically

- Not: CMS, LMS, ERP, simple dashboards

- Yes: Learning systems, intelligent decision models, perception systems

Learning Philosophy

- **Learning ≠ Memorization**

- You will learn:

- *Why* models work

- *When* they fail

- *How* to fix them

- *What* assumptions they make

- Key mindset shift:

- **Accuracy is not success, understanding is success**

Stage 1: Learning How Machines Learn

- **What you will learn**

- AI vs ML vs Deep Learning

- Learning vs Inference

- Overfitting & Generalization

- Regression vs Classification

- Loss functions & optimization

- Gradient Descent

- **Real-world / Industry benefit**

- Understanding **why models fail in production**

- Knowing how training choices affect performance

- Avoiding blindly using libraries

- **Research & FYP benefit**

- Ability to:
  – Design experiments
  – Choose correct loss functions
  – Analyze convergence

- Foundation for **novel model improvements**

Stage 2: Neural Networks as Learning Systems

- **What you will learn**

- Perceptron & Multi-layer Perceptron

- Backpropagation

- Activation functions

- Vanishing / exploding gradients

- Regularization techniques

- Bias–Variance trade-off

- **Real-world / Industry benefit**

- Building **stable and reliable models**

- Improving performance on limited data

- Preventing overfitting in real datasets

- **Research & FYP benefit**

- Modify architectures

- Propose:
  - New regularization ideas
  - Training strategies

- Essential for **paper implementation & extensions**

Stage 3: Visual Intelligence with CNNs

- **What you will learn**

- CNN fundamentals: AlexNet, VGG

- Object detection (YOLO, SSD, R-CNN)

- Semantic segmentation (U-Net, ResNet)

- **Real-world / Industry benefit**

- Used in:

  – Medical imaging

  – Autonomous driving

  – Surveillance

  – Face recognition

  – Manufacturing quality control

- **Research & FYP benefit**

- Compare architectures

- Improve detection of:

  – Small objects

  – Noisy images

  – Low-resolution data

- Strong base for **vision-based FYPs**

Stage 4: Transformers & Modern Architectures

- **What you will learn**

- Why transformers replaced CNNs in many tasks

- Vision Transformers (ViT)

- Attention mechanism intuition

- **Real-world / Industry benefit**

- Backbone of:
  - ChatGPT
  - Vision-language models
  - Multimodal systems

- **Research & FYP benefit**

- Cutting-edge topic

- Ideal for:
  - Comparative studies (CNN vs ViT)
  - Hybrid architectures

- High acceptance in **research papers**

Stage 5: Learning Beyond Images

- **What you will learn**

- *NLP Skipped as you are also studying*

- Graph Neural Networks

- Learning on graphs

- Reinforcement Learning:
  - Q-learning
  - Policy gradients

- **Real-world / Industry benefit**

- Used in:
  - Recommendation systems
  - Social networks
  - Fraud detection
  - Robotics & games

- **Research & FYP benefit**

- Non-traditional data modeling

- Novel problem formulations

- Strong for **unique FYP ideas**

Stage 6: Trustworthy & Explainable AI

- **What you will learn**

- Why interpretability matters

- SHAP, LIME, Grad-CAM

- Model transparency

- **Real-world / Industry benefit**

- Required in:
  - Healthcare
  - Finance
  - Law & policy

- Regulatory compliance

- **Research & FYP benefit**

- Explainability is a **hot research area**

- Analyze model failures

- Improve trust & fairness

How This Course Prepares You for FYP

- **By the end, you can:**

- Read and understand research papers

- Implement published models

- Run experiments

- Compare architectures

- Analyze results scientifically

- Not just "build an app"

- Build a **learning system**

Final Project Expectation

- **Final Project = Research Paper Implementation**

- Must include:

- Literature review

- Model implementation

- Experimental analysis

- Discussion of results

- This course is your **FYP foundation**, not a coding-only subject.

Final Message to Students

- "Deep Learning is not about models.

- it is about **thinking, experimenting, and improving systems**."

Policy and Guidelines

Instructor Information

Instructor	Dr. Zohair Ahmed	E-mail	zohair.ahmed@isb.nu.edu.pk
Current Position	Assistant Professor	**Department**	AI & DS
PhD (AI/NLP) : Central South University, China. **Research Interest** : Natural Language Processing, Multimodal NLP, Sentiment Analysis, Large Language Models, Deep Learning			
Office	203-B, C Block, 2nd Floor	**Tel**	

# Prerequisite(s)
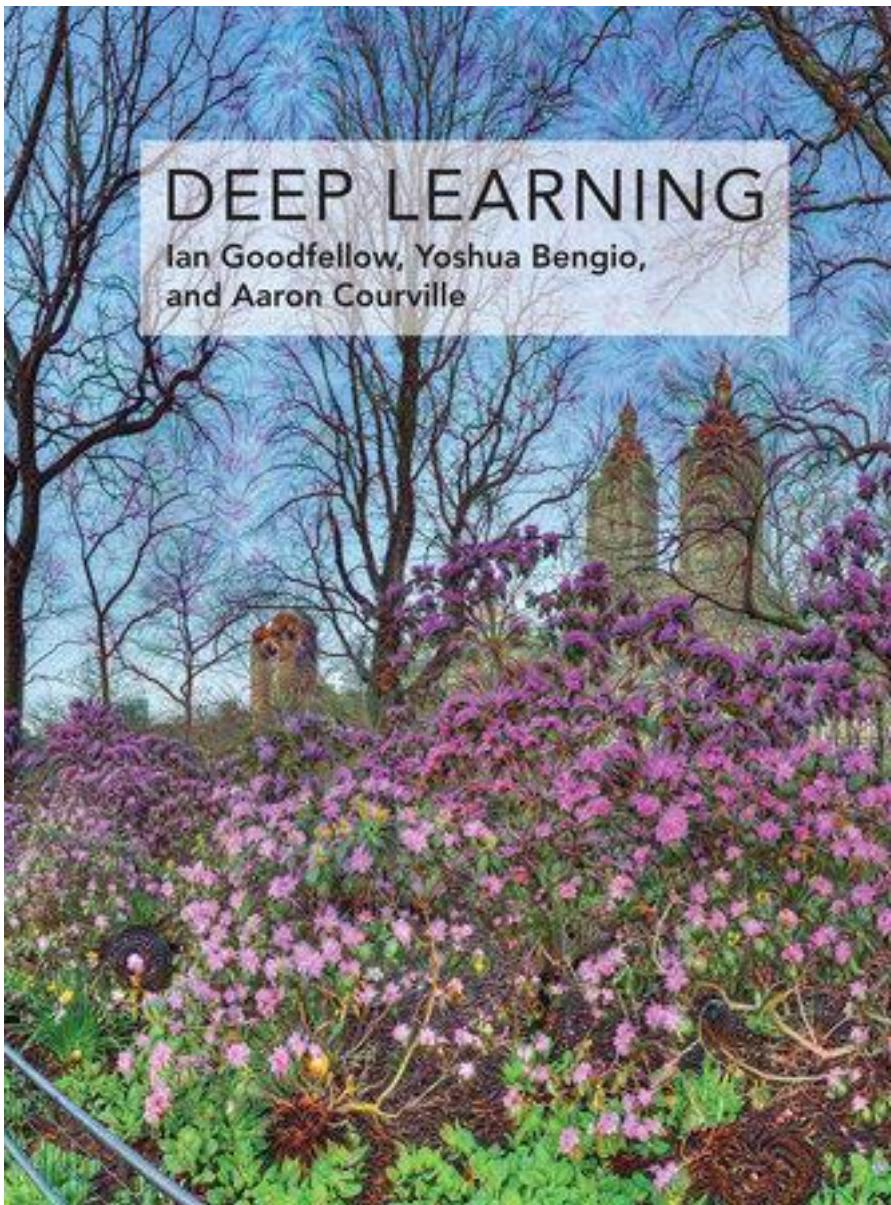
- There is no official prerequisite for this course.

- Concepts of Machine Learning

- Good programming skills especially with one of the following tools:

  – Python / C++/Java

- Machine Learning Frameworks

  – Scikit-Learn

  – **Tensorflow / Keras** , **PyTorch**, DEEPLEARNING4J, Microsoft Cognitive Toolkit, Caffe

Reference Books

- *Deep Learning, by Ian Goodfellow and Yoshua Bengio and Aaron Courville, MIT Press.*

- *Available Online*

Reference Book(s)
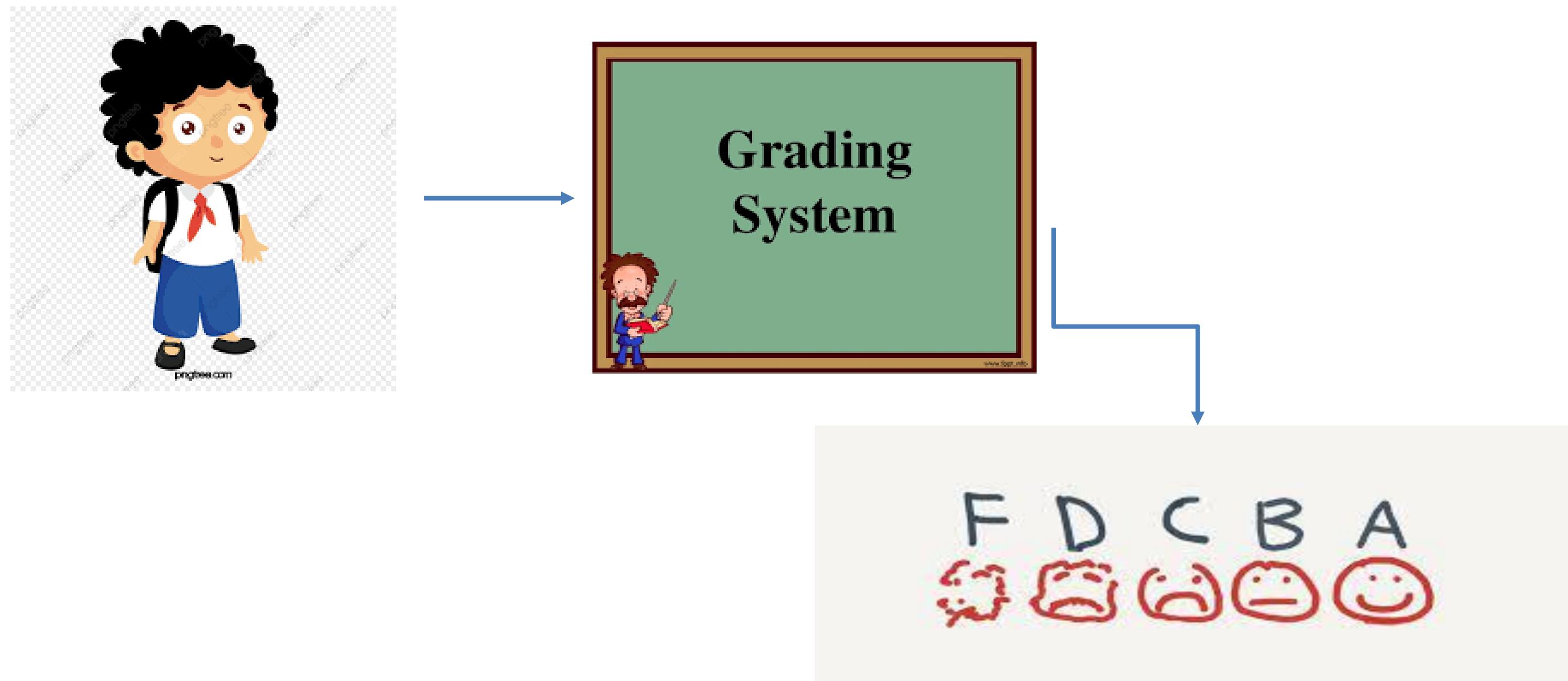
- Research Papers

- Neural Networks and Deep Learning : A Textbook, Charu C. Aggarwal

- Deep Learning with Python, François Cholle

- Machine Learning and Deep Learning with Python, scikit-learn and TensorFlow, Sebastian Raschka and Vahid Mirjalili

Grading Policy

- Absolute Grading

Explanation of Assessment

- All assignments and Quizzes carry equal weightage

- Enough Time will be given for Assignments for their implementation.

- Quizzes can be announced or unannounced.

- Project will be can be done in Groups (max 2-3) or individually.

  – Project include writing a research paper for publication.

  – You will be using **word / Overleaf for Writing the paper** and presenting the results.
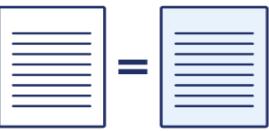
Course Plagiarism Policy

- Plagiarism in any kind of assessment including project or sessional/ final exam, assignments quizzes, will result in F grade in the course.

- So what is it?

> Plagiarism is **presenting someone else's work or ideas as your own, with or without their consent**, by incorporating it into your work without full acknowledgement. All published and unpublished material, whether in manuscript, printed or electronic form, is covered under this definition.

Types of plagiarism

Global plagiarism

Passing off an entire text by someone else as your own
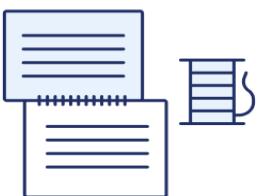
Verbatim plagiarism

Directly copying parts of someone else's work
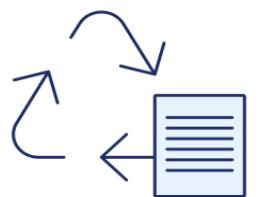
Paraphrasing plagiarism

Rephrasing someone else's ideas to present them as yours

Patchwork plagiarism

Stitching together parts of different sources

Self-plagiarism

Recycling your own past work

Missed Assessment

- Retake of missed assessment items (other than sessional/ final exam) is NOT allowed.

- Missed assessment item (other than sessional / final exam) will earn zero marks

- Late submission will NOT be accepted.

- For missed sessional/ final exam due procedure will be followed.

- No change is any deadline

Course Plagiarism Policy

- Project Paper

  – Plagiarism for paper will be checked via Turnitin software

  – Any paper with score greater than 20% will be considered plagiarized and ZERO marks will be awarded.

  – Content will be also checked for AI Generated plagiarism, it must not exceed 35% too.

Attendance policy

- Students are supposed to have 100% attendance.

- The minimum attendance requirement at all levels and in all courses is 80%.

- The relaxation of 20% attendance has been given only to cover any planned events or unforeseen situations.

- I will take attendance at the start of lecture, within 10 minutes.

  – Ideal: 0 - 10 minutes Present 10-15 mins marked as Late, beyond 15 you will be **marked ABSENT**.

Student Responsibility

- Mobile Usage

  – Use of mobile phones should be avoided.

- Discussion

  – Class participation is highly appreciated

  – You can ask questions in the class(Highly Appreciated)

  – Discussion among students is not allowed.