

# CS4487: MACHINE LEARNING

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## Effective Term

Semester A 2022/23

## Part I Course Overview

### Course Title

Machine Learning

### Subject Code

CS - Computer Science

### Course Number

4487

### Academic Unit

Computer Science (CS)

### College/School

College of Engineering (EG)

### Course Duration

One Semester

### Credit Units

3

### Level

B1, B2, B3, B4 - Bachelor's Degree

### Medium of Instruction

English

### Medium of Assessment

English

### Prerequisites

CS3481 Fundamentals of Data Science or  
SDSC3002 Data Mining

### Precursors

Nil

### Equivalent Courses

Nil

### Exclusive Courses

Nil

## Part II Course Details

### Abstract

The goal of this course is to introduce students to the field of machine learning. Machine learning algorithms allow computers to automatically learn to recognize complex patterns from empirical data, such as text and web documents, images, videos, sounds, sensor-data, and databases. This course is intended to give a broad overview of machine learning from both theoretical and practical standpoints, with emphasis on applying machine learning algorithms to real-world problems. At the end of the course, students will have both working knowledge of and practical experience with machine learning algorithms.

### Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if DEC-A1 DEC-A2 DEC-A3 app.)		
1	Identify and explain common machine learning algorithms.			x
2	Apply machine learning algorithms to solve real-world problems.			
3	Evaluate the effectiveness of different machine learning algorithms and discuss their advantages and disadvantages.		x	
4	Understand theoretical and practical aspects of machine learning algorithms.			

#### A1: Attitude

Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

#### A2: Ability

Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

#### A3: Accomplishments

Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

### Teaching and Learning Activities (TLAs)

	TLAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lecture	The lectures will present selected machine learning algorithms, and the intuition and theory behind them. The algorithms will be illustrated with both toy and real-world examples to motivate the students' understanding. Available software toolboxes will also be discussed.	1, 3, 4	3 hours per week

2	Tutorial	In each week' s tutorial session, students will use machine learning algorithms on small examples to gain better understanding of the lecture material.	1	8 hours per semester
3	Assignment	Students will solve some theoretical and practical problems related to machine learning algorithms, and interpret the results. Students can then have a deeper understanding of the effectiveness of the algorithm, and evaluate the differences between various algorithms.	3, 4	After class, 1 every 3 weeks
4	Course Project	Students will design a system based on a machine learning algorithm to solve a real-world problem. Students will report their results in a course report, and during a poster/ presentation session held at the end of the semester.	2, 3	After class

**Assessment Tasks / Activities (ATs)**

	ATs	CILO No.	Weighting (%)	Remarks (e.g. Parameter for GenAI use)
1	Class participation	1	10	tutorial exercises
2	Assignments	3, 4	30	
3	Course Project and Presentation	2, 3	30	

**Continuous Assessment (%)**

70

**Examination (%)**

30

**Examination Duration (Hours)**

2

**Additional Information for ATs**

For a student to pass the course, at least 30% of the maximum mark for the examination AND course project must be obtained.

## Assessment Rubrics (AR)

### Assessment Task

Class participation

### Criterion

1.1 CAPACITY for LEARNING about machine learning algorithms.

#### Excellent (A+, A, A-)

High

#### Good (B+, B, B-)

Significant

#### Fair (C+, C, C-)

Moderate

#### Marginal (D)

Basic

#### Failure (F)

Not even reaching marginal levels

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### Assessment Task

Assignments

### Criterion

2.1 ABILITY to DERIVE and ANALYSE machine learning algorithms and INTERPRET the results.

2.2 ABILITY to COMPARE machine learning algorithms theoretically and empirically.

#### Excellent (A+, A, A-)

High

#### Good (B+, B, B-)

Significant

#### Fair (C+, C, C-)

Moderate

#### Marginal (D)

Basic

#### Failure (F)

Not even reaching marginal levels

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### Assessment Task

Course Project and Presentation

### Criterion

3.1 ABILITY to APPLY machine learning to real-world problems and INTERPRET the results.

3.2 ABILITY to EVALUATE, COMPARE, and CONTRAST different machine learning algorithms.

**Excellent (A+, A, A-)**

High

**Good (B+, B, B-)**

Significant

**Fair (C+, C, C-)**

Moderate

**Marginal (D)**

Basic

**Failure (F)**

Not even reaching marginal levels

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**Assessment Task**

Examination

**Criterion**

4.1 ABILITY to EXPLAIN, DERIVE and ANALYSE machine learning algorithms, and INTERPRET results from machine learning algorithms.

4.2 ABILITY to EVALUATE, COMPARE, and CONTRAST different machine learning approaches.

**Excellent (A+, A, A-)**

High

**Good (B+, B, B-)**

Significant

**Fair (C+, C, C-)**

Moderate

**Marginal (D)**

Basic

**Failure (F)**

Not even reaching marginal levels

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## Part III Other Information

### Keyword Syllabus

Topics include statistical learning, data clustering, dimensionality reduction and data visualization, discriminative classifiers. Programming assignments will touch the following applications: document analysis, spam detection, document clustering, image segmentation, data visualization, face detection, face recognition.

### Syllabus

- Overview of machine learning with real-world examples
- Statistical learning
  - probability distributions (univariate)
  - parameter estimation (maximum likelihood)
  - Bayes' rule & MAP classifiers

- multivariate probability distributions
- linear and lasso regression
- Data clustering
  - k-means
  - Gaussian mixture models and the EM algorithm
  - Dimensionality reduction and visualization
  - subspace methods (PCA, LDA, NMF, SVD)
  - independent component analysis
- Discriminative classifiers
  - k-nearest neighbours
  - bayes optimal classifier
  - logistic regression
  - naive bayes
  - linear discriminant analysis
  - support vector machines (convex optimization and duality)
- Deep learning and Neural Networks
  - Perceptron, multi-layer perceptron
  - Activation functions
  - Backpropagation, stochastic gradient descent
  - Convolutional neural networks
  - Regularization, batch-norm, dropout
  - Architectures: Resnet, Densenet, fully convolutional network
  - Autoencoder
  - Generative adversarial network, variational autoencoder
- Recommender systems

## Reading List

### Compulsory Readings

Title	
1	P. Harrington (2012). Machine Learning in Action. Manning.

### Additional Readings

Title	
1	A. Rajaraman, and J. Ullman (2011). Mining of Massive Datasets. Cambridge University Press. (online: <a href="http://infolab.stanford.edu/~ullman/mmds.html">http://infolab.stanford.edu/~ullman/mmds.html</a> )
2	H. Daume III. A course in Machine Learning. (online: <a href="http://ciml.info/">http://ciml.info/</a> )
3	C.M. Bishop (2006). Pattern Recognition and Machine Learning. Springer.
4	R.O. Duda, P.E. Hart, & D.G. Stork (2001). Pattern Classification. Wiley-Interscience, 2nd edition.
5	T. Hastie, R. Tibshirani, and J. Friedman (2009). The Elements of Statistical Learning: Data Mining, Inference, and Prediction. Springer-Verlag, 2nd edition.