Institute: Women's Institute of Technology and Innovation, WITI

Course Name: Mathematical Computing Course Outline

Course Code: CSD 115

Facilitator: Muhame B. Alon

Period: May – August 2022

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GitHub Rep for the course: https://github.com/alon-muhame/WITI-CS-Maths

Basic mathematical tools and methods needed for computer science are introduced. Elementary mathematical skills for defining, analysing and reasoning with abstract objects used in programming are developed. Topics include integers and rational numbers, strings and sets, algorithms and functions, and elementary introductions to probability

This course is a core part of the Computer Science major. It focuses on laying theoretical foundations of mathematics which are further developed and applied in Introduction to python programming, machine learning, and more advanced courses on algorithms, machine learning.

Key topics to cover

1. Review of Sets and Number Theory.
2. Introduction to probability.
3. Introduction to Linear Algebra
4. All the above topics applied to python code and examples

Learning outcomes

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

1. Use and apply counting and probability techniques. Students should be comfortable with basic ideas in probability and counting, and applying them in easy real-life settings (for example, counting arrangements of items, computing expectation of a discrete random variable). (Capability 4 and 5)
2. Communicate mathematically. Students should be able to read and interpret basic mathematical symbols and notation (for example, standard terminology of numbers, sets, functions, strings, trees and graphs), and be capable of translating and communicating their own ideas into mathematical language. (Capability 1, 2 and 4)
3. Linear algebra notation understanding and be able to complete matrix computations (be able to complete matrix addition, multiplication, subtraction).
4. Be able to use python – Jupyter notebooks to write simple and clear code to apply some of the theoretical concepts learned from the course.

Unit: Probability

Chapter 14: Events and probability spaces (PDF)
Chapter 15: Conditional probability (PDF)
Chapter 16: Independence (PDF)
Chapter 17: Random variables and distributions (PDF)

Unit: Linear Algebra

Chapter 1: Basic Concepts and Notation
Chapter 2: Matrix Multiplication
Chapter 3: Operations and Properties

Unit: Hands-on with Python and Jupyter notebooks

Unit 1: Linear Algebra

Getting started

- Presentation: What is linear algebra? Why learn linear algebra?
- Why Python?
- Why Jupyter Notebooks

Vectors, combining, and scaling

- Presentation: What are vectors? Combining and scaling vectors; span and linear dependence
- Hands-on exercises: Add and scale vectors in NumPy; add and scale vectors

Transforming vectors and matrices

- Presentation: Basis vectors, matrices, the determinant
- Hands-on exercises: Matrices and the determinant in NumPy; transform a vector

System of linear equations and inverse matrices

- Presentation: Solving systems of linear equations with inverse matrices
- Hands-on exercises: Solving systems of linear equations with NumPy; a word problem

Dot products

- Presentation: Understanding dot products, orthogonality
- Hands-on exercises: Dot products with NumPy; execute a dot product

Matrix decomposition

- Presentation: Matrix decomposition, eigenvectors, and eigenvalues
- Hands-on exercises: Matrix decomposition with NumPy; decompose a matrix

Number theory

- Presentation: Number theory; natural numbers, integers, rational, and irrational numbers
- Hands-on exercise: Identify numeric types

Mathematical expressions

- Presentation: Mathematical expressions; order of operations

Mathematical functions

- Presentation: Intuition behind mathematical functions
- Discussions: Thinking about infinity; linear and nonlinear functions
- Hands-on exercise: How many possible values are there in this function range?

Exponential functions

- Presentation: Rules for exponents; rational and irrational exponents
- Hands-on exercise: Simplify the exponential expressions

Logarithmic functions

- Presentation: Rules for logarithms
- Hands-on exercises: Logarithms in Python; evaluate the logarithmic expressions

Unit 2: Probability

Introduction and getting started

- Discussion: Main applications of Probability
- Presentation: Introduction to probability?

Understanding probability

- Presentation: Difference Frequentist and Bayesian probability; odds ratios
- Hands-on exercise: Want to make a bet?

Adding and multiplying probabilities

- Presentation: Joint probability; union probability
- Hands-on exercises: Independent events and joint probability; rain and union probability

Conditional probability

- Presentation: Conditional probability and colorblindness
- Hands-on exercise: Rain and conditional probability

- Break

Bayes' theorem

- Presentation: Violence and video games
- Hands-on exercise: Medical testing accuracy

Binomial distribution

- Presentation: Binomial distribution
- Hands-on exercise: Airline empty seats

Normal distribution (15 minutes)

- Presentation: Normal distribution; quantile functions

Assessment Type	Percentage	Classification
Assignments	20%	Individual Coursework
Final Exam	50%	Individual Examination
Mid Semester Quiz	30%	Individual Test
5 types	100%	
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5 types	100%	

- Hands-on exercise: Predict life expectancy of a phone

Delivery Mode & Assessments

Campus Experience
Attendance is required at scheduled activities including labs to receive credit for components of the course.
Lectures will be available as recordings. Other learning activities including tutorials will not be available as recordings.
The course will not include live online events including tutorials.
Attendance on campus is required for the test/exam.
The activities for the course are scheduled as a standard weekly timetable

Academic Integrity

The Institute will not tolerate cheating, or assisting others to cheat, and views cheating in coursework as a serious academic offence. The work that a student submits for grading must be the student's own work, reflecting their learning. Where work from other sources is used, it must be properly acknowledged and referenced. This requirement also applies to sources on the internet. A student's assessed work may be reviewed against online source material using computerised detection mechanisms.

Some References [not exhaustive]

Reference for this Chapter:

1. *Mathematics for Computer Science, 8th September, 2010, 00:40 by Eric Lehman, Tom Leighton, and Albert Meyer.*
2. *https://numpy.org/*
3. *Teaching and Learning with Jupyter: Lorena A. Barba, Lecia J. Barker, Douglas S. Blank, Jed Brown, Allen B. Downey, Timothy George, Lindsey J. Heagy, Kyle T. Mandli, Jason K. Moore, David Lippert, Kyle E. Niemeyer, Ryan R. Watkins, Richard H. West, Elizabeth Wickes, Carol Willing, and Michael Zingale*
4. *I will share an elaborate reference of materials on the repo.*