

CTYI “MATHS WITH APPLICATIONS”: COURSE OUTLINE SPRING 2021

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INTRODUCTION

Welcome to the CTYI course *Maths with Applications*.

Pure mathematics is a subject so broad it is unclear where it begins and ends. We will strive to see how pure mathematics is applied to various disciplines, including finance, game theory, astronomy, and computer science: all subjects seriously considered by academics and major corporations across the world. We will focus on each of the below topics, discussing some of the theory then solving problems with what we know. The following is a brief outline of how the course is organised and what I hope we can tackle in the coming weeks.

TOPIC 1: PROBABILITY PUZZLES

- *Introduction & Examples.*
- *Expected payoff, long and short odds, conditional probability.*

Sample question: What is the probability two people in the class share a birthday?

TOPIC 2: GAME THEORY

- *Introduction & Examples.*
- *Some simple games, the Dark Knight.*
- *Hex: an example game requiring proof and strategy.*

Sample question: How would you model the 2016 US presidential election?

TOPIC 3: COMPUTABILITY THEORY

- *An introduction to computers and algorithms.*
- *What are computers incapable of?*

Sample question: Is it possible to create a computer program to determine when equations have whole number solutions?

TOPIC 4: TRIGONOMETRY & ASTRONOMY

- This week will be based on Professor Terrance Tao’s 2020 Hamilton Lecture, on “The Cosmic Distance Ladder”. We will study how to use small local measurements to measure large and far away celestial objects.

Sample question: While standing on Earth, how can you measure its circumference (given no measuring tape long enough exists)?

TOPIC 5: MACHINE LEARNING

- *Basic concepts & Examples.*
- *What is “Deep Learning” and what can it do?*

Sample question: How can a machine be trained quickly and easily to recognise handwriting it has never seen before?