

**New**

# Master of Science in **ARTIFICIAL INTELLIGENCE**

*Nurturing talents in artificial intelligence*

**Apply now for entry in September 2022**

# IS THE PROGRAMME FOR YOU

Why this Programme

In this day and age, there is no doubt that artificial intelligence has become an indispensable part of our daily lives. Intelligence machines are everywhere, and enhanced efficiency and augmentation of human capabilities are among the upsides. One example of AI is machine learning, which means that machines can observe, analyze and make mistakes similar to human brains without being taught to do so. The prevalence of AI has powered its applications in different areas, such as scientific research, transportation and marketing. It is predicted that in future, AI will continue to be one of the most in-demand jobs.

The Master of Science in Artificial Intelligence [MSc(AI)] is an interdisciplinary taught postgraduate programme jointly offered by the Department of Mathematics (host), the Department of Statistics & Actuarial Science and the Department of Computer Science. Its academic focus is promoting the applications of mathematics, statistics and computer science to facilitate AI in decision-making and problem-solving for various organizations and enterprises within the private and public sectors.

## World-class Rankings of HKU


### Quacquarelli Symonds (QS)

 **#22** World Rankings 2022  
**#4** Asia Rankings 2021

### Times Higher Education (THE)

 **#30** World Rankings 2022  
**#4** Asia Rankings 2021

### Eminent Subject Ranking

 QS World University Rankings by Subject 2021:  
**#53** Mathematics

### Top-notch Scientists in the Faculty

Clarivate Analytics' Essential Science Indicators 2020  
**16.5%** of our professoriate staff are the world's Top 1% scholars

## Interdisciplinary and well-balanced curriculum

- ◇ Solid training in diverse techniques used in AI from the core courses
- ◇ Electives over related topics from mathematics, statistics and computer science
- ◇ A capstone project with real-life applications
- ◇ Guest lectures by distinguished scholars and industry experts
- ◇ Internship opportunities in the AI industry and academia

## Learning within and beyond AI

- ◇ Students will learn the AI-related applications of mathematics, statistics and computer science to solve real-life problems
- ◇ The theoretical elements in the curriculum will help students develop essential intellectual capacity at large

## Industry connections and career prospects

- ◇ Teaching team has strong connections with high-tech industries in the Greater Bay Area
- ◇ Our graduates are expected to be well prepared for careers such as software engineers, consultants and research scientists in AI and related fields such as big data and financial technology

## Programme Information



### Tuition fees

**Composition fee: HK\$260,000<sup>#</sup>** (subject to approval)  
Students are required to pay Caution Money (HK\$350, refundable on graduation subject to no claims being made) and Graduation Fee (HK\$350)



### Programme duration

Full-time: 1.5 years



### Study load

Credits: 72 credits  
Learning hours: 1,440 – 2,160 hours (including 240-360 hours for project and contact hours of 264-396 hours)



### Class schedule

Teaching takes place mainly on weekdays. Classes may also be arranged on Saturdays if needed.



### Medium of Instruction

English



### Scholarships

Different types of scholarships will be offered.



### Assessment

- Mainly written and programming coursework, and/or examinations
- A Capstone Project on a topic of the student's choice

<sup>#</sup>The fee shall generally be payable in 3 instalments over 1.5 years for full-time

## Where will this Programme Lead You

### Transferable skills

- ◇ Equip students with the solid foundation in both theory and practice in artificial intelligence and the underlying mathematical and statistical tools
- ◇ The practical elements in the courses help students develop essential intellectual capacity and skills, including but not limited to image processing, pattern recognition, financial technology, robotics and quantum computing and so on
- ◇ Students will learn the applications of mathematics, statistics and computer science to decision-making and problem-solving in all organizations and enterprise within the private and public sectors
- ◇ Students will be able to apply the methodologies learnt ethically and effectively in different academic or professional disciplinary areas

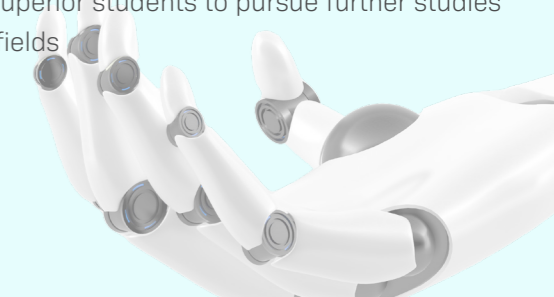
## Host

### Department of Mathematics

Addressing the need for talents in the field of artificial intelligence, the Department of Mathematics is delighted to announce the launch of the new Master of Science in Artificial Intelligence programme. With contributions from the Department of Statistics & Actuarial Science and the Department of Computer Science, we adopt an interdisciplinary academic focus to make our programme a comprehensive study in artificial intelligence.

## Who should Take this Programme

- ◇ Candidates with a bachelor's degree in subjects including but not limited to mathematics, statistics, computer science and engineering discipline
- ◇ University graduates and young professionals who aspire to pursue a career in this booming field
- ◇ Scholastically superior students to pursue further studies in the relevant fields



Programme Features

## Programme structure

Design of curriculum (72 credits)	
<b>Compulsory courses (42 credits)</b>	
ARIN7001 Foundations of artificial intelligence (6 credits)	
ARIN7011 Optimization in artificial intelligence (6 credits)	
ARIN7013 Numerical methods in artificial intelligence (6 credits)	
ARIN7101 Statistics in artificial intelligence (6 credits)	
ARIN7102 Applied data mining and text analytics (6 credits)	
COMP7404 Computational intelligence and machine learning (6 credits)	
DASC7606 Deep learning (6 credits)	
<b>Disciplinary electives (18 credits)</b> with at least 6 credits from each of the following lists	
<b>List A:</b>	
ARIN7014 Topics in advanced numerical analysis (6 credits)	
ARIN7015 Topics in artificial intelligence and machine learning (6 credits)	
MATH7224 Topics in advanced probability theory (6 credits)	
MATH8502 Topics in applied discrete mathematics (6 credits)	
MATH8503 Topics in advanced optimization (6 credits)	
<b>List B:</b>	
STAT6011 Computational statistics (6 credits)	
STAT7008 Programming for data science (6 credits)	
STAT8020 Quantitative strategies and algorithmic trading (6 credits)	
STAT8021 Big data analytics (6 credits)	
<b>List C:</b>	
COMP7308 Introduction to unmanned systems (6 credits)	
COMP7309 Quantum computing and artificial intelligence (6 credits)	
COMP7409 Machine learning in trading and finance (6 credits)	
COMP7502 Image processing and computer vision (6 credits)	
ARIN7017 Legal issues in artificial intelligence and data science (6 credits)	
<b>Capstone project (12 credits)</b>	
ARIN7600 Artificial intelligence project (12 credits)	

### Remarks:

- Students who have completed the same or similar courses in their previous studies may, on submission of relevant transcripts, be permitted to select up to 18 credits of disciplinary electives from the other two lists if they are not able to find any untaken options from any one of the lists of disciplinary electives.
- The programme structure will be reviewed from time to time and is subject to change.

## Compulsory Courses

### ARIN7001 Foundations of artificial intelligence

This course introduces foundational knowledge, methods and tools in mathematics, statistics and computer science for the purpose of studying and applying artificial intelligence.

### ARIN7011 Optimization in artificial intelligence

This course introduces students to the topics in theory and algorithms of optimization that play important roles in artificial intelligence and machine learning. Topics include: 1) Fundamental optimization models in AI (linear programming models, integer programming models, network models, reinforcement learning and deep learning models, etc.); 2) Optimization theory in AI (optimality conditions, constraint qualification, global

landscape analysis of deep neural networks, P- and NP-hard problems, approximation algorithms, preliminary graph theory, etc.), 3) Optimization algorithms in AI: (a) Classic algorithms (simplex method, interior point method, branch and bound method, cutting plane method, representative algorithms, gradient type methods, CG methods, projection methods, penalty method, Lagrange methods, quasi-Newton methods, Newton type methods), (b) Stochastic algorithms (stochastic gradient descent (SGD), stochastic coordinate descent methods, subsampled Newton, stochastic quasi-Newton), (c) Algorithms for large-scale optimization problems (Operator splitting algorithms (BCD type algorithms, ADMM, primal-dual type algorithms, etc.), centralized/decentralized algorithms,

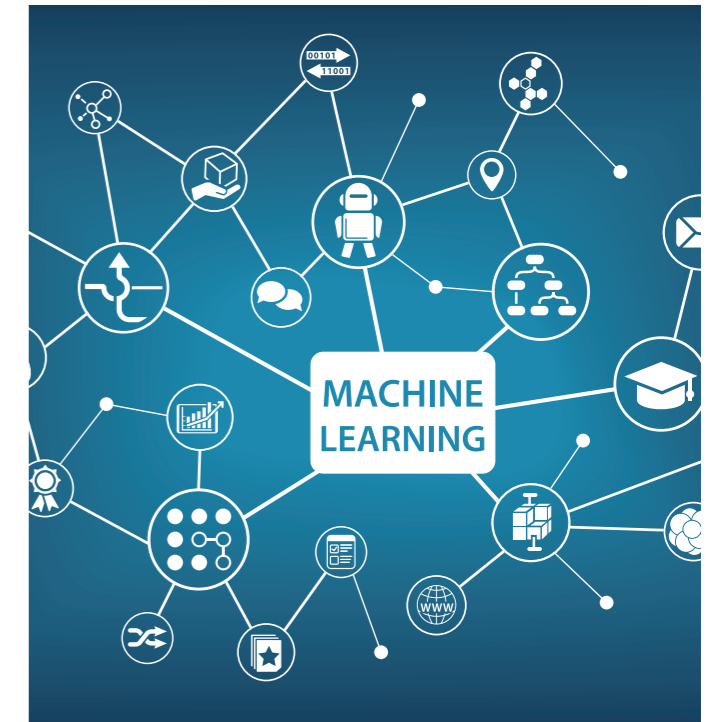
etc.). (d) Algorithms for nonconvex optimization and training deep neural networks.

### ARIN7013 Numerical methods in artificial intelligence

This course introduces students to the numerical methods that are instrumental in artificial intelligence and machine learning. Topics include: 1) Notions and concepts in numerical analysis (convolution matrix (related to CNN), kernel methods, pattern analysis, direct methods for sparse matrices). 2) Numerical method for solving linear systems (Jacobi Method, Gauss-Seidel method, Cholesky decomposition, singular value decomposition (SVD), low-rank matrix approximation, with applications in artificial intelligence and machine learning). 3) Principal component analysis, tensor decomposition and their applications to computer vision, image processing and artificial intelligence and machine learning in general. 4) Compute eigenvalues and eigenvectors (Rayleigh quotient, with applications in artificial intelligence and machine learning). 5) Numerical methods for ordinary differential equations (stability, convergence analysis, relation between the SGD and Euler method, using DNN to compute ODEs).

### ARIN7101 Statistics in artificial intelligence

The development of artificial intelligence has revolutionized the theory and practice of statistical learning, while novel statistical learning approaches are becoming an integral part of artificial intelligence.



By focusing on the interplay between statistical learning and artificial intelligence, this course reviews the main concepts underpinning classical statistical learning, studies computer-intensive methods for conducting statistical learning, and examines important issues concerning statistical learning drawn upon modern artificial intelligence technologies. Contents include classical frequentist and Bayesian inferences, resampling methods, large-scale hypothesis testing, regularization, and high-dimensional modelling.

### ARIN7102 Applied data mining and text analytics

With the rapid developments in computer and data storage technologies, the fundamental paradigms of classical data analysis are mature for change. Data mining aims at automated discovery of underlying structure and patterns in large amounts of data, especially text data. This course takes a practical approach to acquaint students with the new generation of data mining tools and techniques, and show how to use them to make informed decisions. Topics include data preparation, feature selection, association rules, decision trees, bagging, random forests and gradient boosting, cluster analysis, neural networks, introduction to text mining.

### COMP7404 Computational intelligence and machine learning

This course will teach a broad set of principles and tools that will provide the mathematical, algorithmic and philosophical framework for tackling problems using Artificial Intelligence (AI) and Machine Learning

# WHAT YOU WILL LEARN

(ML). AI and ML are highly interdisciplinary fields with impact in different applications, such as biology, robotics, language, economics, and computer science. AI is the science and engineering of making intelligent machines, especially intelligent computer programmes, while ML refers to the changes in systems that perform tasks associated with AI. Ethical issues in advanced AI and how to prevent learning algorithms from acquiring morally undesirable biases will be covered.

Topics may include a subset of the following: problem solving by search, heuristic (informed) search, constraint satisfaction, games, knowledge-based agents, supervised learning, unsupervised learning; learning theory, reinforcement learning and adaptive control and ethical challenges of AI and ML.

## DASC7606 Deep learning

Machine learning is a fast-growing field in computer science and deep learning is the cutting edge technology that enables machines to learn from large-scale and complex datasets. Ethical implications of deep learning and its applications will be covered and the course will focus on how deep neural networks are applied to solve a wide range of problems in areas such as natural language processing and image processing. Other applications such as financial predictions, game

playing and robotics may also be covered. Topics covered include linear and logistic regression, artificial neural networks and how to train them, recurrent neural networks, convolutional neural networks, generative models, deep reinforcement learning, and unsupervised feature learning.

## Disciplinary Electives

### ARIN7014 Topics in advanced numerical analysis

This course covers a selection of topics in advanced numerical analysis, which may include: 1) Krylov subspace, generalized minimal residual method (GMRES); 2) numerical (partial) differential equations; 3) stochastic methods and their applications to artificial intelligence and machine learning; 4) approximation theory, high-dimensional approximation (MC, QMC, sparse grid method); 5) Fourier analysis, wavelet analysis; 6) robust PCA and dimensional reduction methods. The selected topics may vary from year to year.

### ARIN7015 Topics in artificial intelligence and machine learning

Selected topics in artificial intelligence that are of current interest will be discussed in this course.

MATH7224 Topics in advanced probability theory  
Selected topics in probability theory will be discussed in this course.

### MATH8502 Topics in applied discrete mathematics

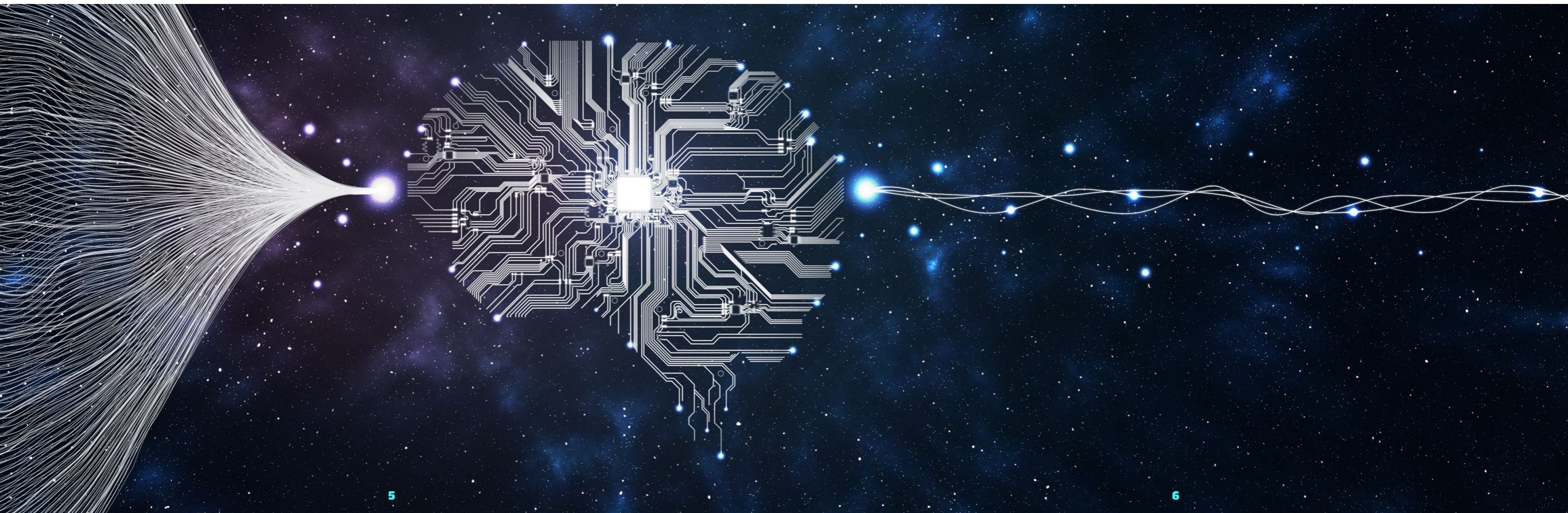
This course aims to provide students with the opportunity to study some further topics in applied discrete mathematics. A selection of topics in discrete mathematics applied in combinatorics and optimization (such as algebraic coding theory, cryptography, discrete optimization, etc.) The selected topics may vary from year to year.

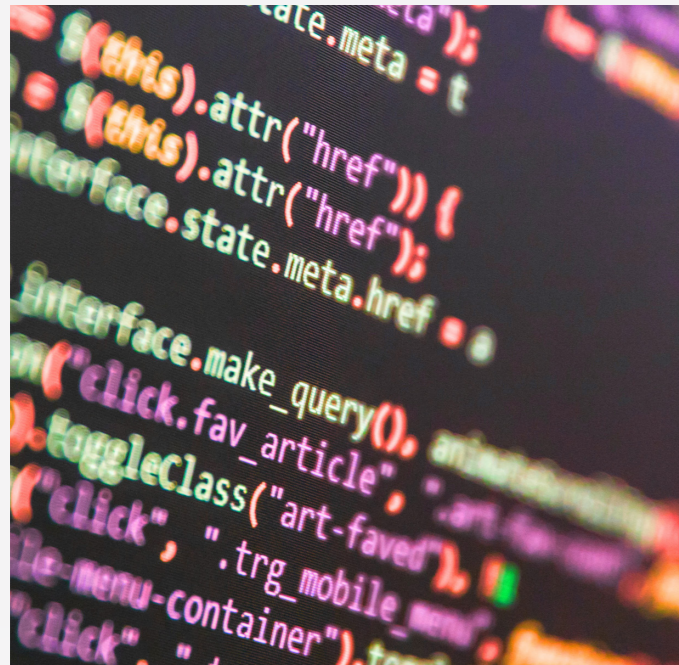
### MATH8503 Topics in advanced optimization

A study in greater depth of some special topics in mathematical programming or optimization. It is mainly intended for students in Operations Research or related subject areas. This course covers a selection of topics which may include convex programming, nonconvex programming, saddle point problems, variational inequalities, optimization theory and algorithms suitable for applications in various areas such as machine learning, artificial intelligence, imaging and computer vision. The selected topics may vary from year to year.

### STAT6011 Computational statistics

This course aims to give students a background in modern computationally intensive methods in statistics. It emphasizes the role of computation as a fundamental tool of discovery in data analysis, of statistical inference, and for development of statistical theory and methods. Contents include: Bayesian statistics, Markov chain Monte Carlo methods including Gibbs sampler, the Metropolis-Hastings algorithm, and data augmentation; Generation of random variables including the inversion methods, rejection sampling, the sampling/importance resampling method; Optimization techniques including Newton's method, expectation-maximization (EM) algorithm and its variants, and minorization-maximization (MM) algorithms; Integration including Laplace approximations, Gaussian quadrature, the importance sampling method, Numerical optimization and integration, EM algorithm and its variants, Simulation and Monte Carlo integration, Importance sampling and variance reduction techniques; and other topics such as Hidden Markov models, neural networks, and Bootstrap methods.





## STAT7008 Programming for data science

In the big data era, it is very easy to collect huge amounts of data. Capturing and exploiting the important information contained within such datasets poses a number of statistical challenges. This course aims to provide students with a strong foundation in computing skills necessary to use R or Python to tackle some of these challenges. Possible topics to be covered may include exploratory data analysis and visualization, collecting data from a variety of sources (e.g. Excel, web-scraping, APIs and others), object-oriented programming concepts and scientific computation tools. Students will learn to create their own R packages or Python libraries.

## STAT8020 Quantitative strategies and algorithmic trading

Quantitative trading is a systematic investment approach that consists of identification of trading opportunities via statistical data analysis and implementation via computer algorithms. This course introduces various methodologies that are commonly employed in quantitative trading.

The first half of the course focuses on strategies and methodologies derived from the data snapshot at daily or minute frequency. Some specific topics are: (1) techniques for trading trending and mean-reverting instruments, (2) statistical arbitrage and pairs trading, (3) detection of 'time-series' mean reversion or stationarity, (4) cross-sectional momentum and contrarian strategies, (5) back-testing methodologies and corresponding performance measures, and (6) Kelly formula, money and risk management. The second

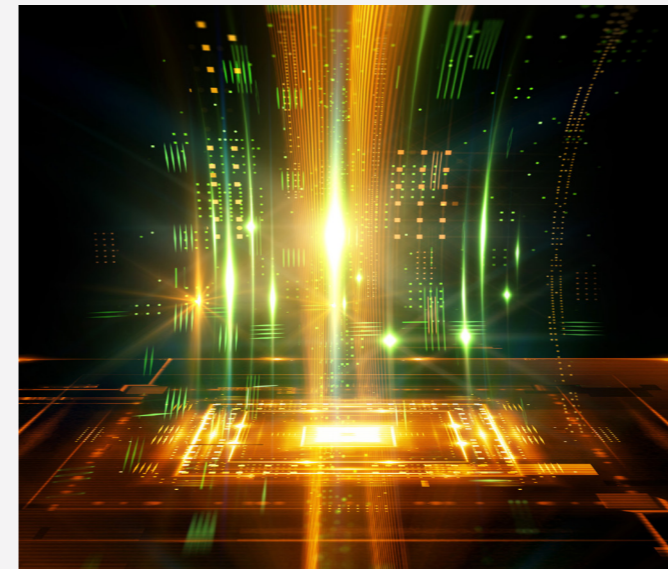
half of the course discusses statistical models of high frequency data and related trading strategies. Topics that planned to be covered are: (7) introduction of market microstructure, (8) stylized features and models of high frequency transaction prices, (9) limit order book models, (10) optimal execution and smart order routing algorithms, and (11) regulation and compliance issues in algorithmic trading.

## STAT8021 Big data analytics

The recent explosion of social media and the computerization of every aspect of life resulted in the creation of volumes of mostly unstructured data (big data): web logs, e-mails, videos, speech recordings, photographs, tweets and others. This course aims to provide students with knowledge and skills of some advanced analytics and statistical modeling for solving big data problems. Topics include recommender system, deep learning: CNN, RNN, LSTM, GRU, natural language processing, sentiment analysis and topic modeling. Students are required to possess basic understanding of Python language.

## COMP7308 Introduction to unmanned systems

This course is to study the theory and algorithms in unmanned systems. Topics include vehicle modeling, vehicle control, state estimation, perception and mapping, motion planning, and deep learning related techniques.



## COMP7309 Quantum computing and artificial intelligence

This course offers an introduction to the interdisciplinary fields of quantum computation and quantum AI. The focus will lie on an accessible introduction to the elementary concepts of quantum mechanics, followed by a comparison between computer science and information science in the quantum domain. The theoretical capability of quantum computers will be illustrated by analyzing fundamental algorithms of quantum computation and their potential applications in AI.

## COMP7409 Machine learning in trading and finance

The course introduces students to the field of Machine Learning and help them develop skills of applying Machine Learning, or more precisely, applying supervised learning, unsupervised learning and reinforcement learning to solve problems in Trading and Finance.

This course will cover the following topics. (1) Overview of Machine Learning and Artificial Intelligence, (2) Supervised Learning, Unsupervised Learning and Reinforcement Learning, (3) Major algorithms for Supervised Learning and Unsupervised Learning with applications to Trading and Finance, (4) Basic algorithms for Reinforcement Learning with applications to optimal trading, asset management, and portfolio optimization, (5) Advanced methods of Reinforcement Learning with applications to high-frequency trading, cryptocurrency trading and peer-to-peer lending.

## COMP7502 Image processing and computer vision

This course is to study the theory and algorithms in image processing and computer vision. Topics include image representation, image enhancement, image restoration,

mathematical morphology, image compression, scene understanding and motion analysis.

## ARIN7017 Legal issues in artificial intelligence and data science

Modern information systems have had unprecedented impact on privacy while building dependency on them. The immense social benefits of such systems as data mining and cloud computing must be weighed against potential dangers with consideration of methods of mitigation of risk.

This course examines the growing legal, administrative, policy and technical issues associated with the use of artificial intelligence and information security and assurance. In particular, the relationship of data mining to information assurance and privacy are analyzed, and legislative responses studied.

## Capstone Project

### ARIN7600 Artificial intelligence project

Students will be required to attend an artificial intelligence ethics workshop and then carry out independent work on a major project under the supervision of staff members. A research report as well as an oral presentation on the research work and related ethics issues are required.

More course information at:

<https://www.scifac.hku.hk/prospective/tpg/ArtificialIntelligence>





“Tapping into the AI expertise of our teaching team, we set out to nurture talents who will be geared up to meet the mounting demand for AI professionals both in Hong Kong and worldwide.”

## Programme Director and Head of Department of Mathematics

**Professor Xiaoming YUAN**

BSc, MPhil Nanjing U; PhD City U

### Academic staff

#### Department of Mathematics

Professor W K CHING

BSc, MPhil HK; PhD CUHK

Professor G HAN

BSc, MSc Peking U; PhD Notre Dame

Dr B KANE

BSc, MSc Carnegie Mellon; PhD Wisconsin

Dr G LI

MS Fudan; PhD Texas A&M

Professor M K P NG

MPhil HK; PhD CUHK

Dr Z QU

BSc, MSc, PhD Ecole Polytechnique

Dr Y WANG

BSc NWPU; PhD TAMU

Dr T K WONG

BSc, MPhil CUHK; PhD NYU

Professor X YUAN

BSc, MPhil Nanjing U; PhD City U

Professor W ZANG

BSc NUDT; MSc Academia Sinica; PhD Rutgers

Dr Z ZHANG

BS, PhD Tsinghua

#### Department of Statistics and Actuarial Science

Dr Y CAO

BS Fudan; MS, PhD Princeton

Dr C W KWAN

BSc, PhD HK

Dr A S M LAU

BEng City; MSc HK; PhD CUHK

Dr E A L LI

BSc HK; MEcon, PhD Syd

Professor G D LI

BSc, MSc Peking; PhD HK

Professor G S YIN

MA Temple; MSc, PhD N Carolina

#### Department of Computer Science

Dr K P CHOW

MA, PhD UC Santa Barbara

Professor F Y L CHIN

BASc Toronto; MSc, MA, PhD Princeton

Professor T KOMURA

PhD Tokyo

Dr L KONG

PhD Carnegie Mellon University

Dr P LUO

PhD CUHK

Dr J PAN

PhD North Carolina, Chapel Hill

Dr D SCHNIEDERS

PhD HK

Professor W WANG

BSc, MEng Shandong; PhD Alberta

Dr K K Y WONG

BEng CUHK; MPhil, PhD Cambridge

Professor Y Z YU

PhD UC Berkeley

## Admissions

### Requirements

- ◇ A Bachelor's degree with honours, or equivalent qualification;
- ◇ Applicants should possess knowledge of linear algebra, calculus, probability theory, introductory statistics and computer programming; and
- ◇ Fulfil the University Entrance Requirements.

### How to apply

Main Round Deadline: **12 noon, January 31, 2022 (GMT+8)**

Clearing Round Deadline: extended to **12 noon, April 29, 2022 (GMT+8)**

### Online application



[admissions.hku.hk/tpg](https://admissions.hku.hk/tpg)

## Further Information

### Programme details



[bit.ly/3n0cBZa](https://bit.ly/3n0cBZa)

### Support for students



[www.cedars.hku.hk/](https://www.cedars.hku.hk/)

### Enquiries


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## Faculty of Science


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