

*Introduction to Major and Minor  
in Mathematics  
(Advanced Courses)*

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*Department of Mathematics, HKU*

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# *Major in Mathematics*

Most math majors will concentrate on one of the following three main themes:

- **(Pure) Mathematics**
- **Computational Mathematics, Logistics/  
Operations Research**
- **Mathematics, Economics and Finance**

# MATH3301 Algebra I

- Introduction to groups, rings and fields.
- Useful to MATH4302 Algebra II, MATH6501 Topics in Algebra and MATH6502 Topics in Applied Discrete Mathematics.
- Teacher: Prof. J.T. Yu (*Notre Dame*)

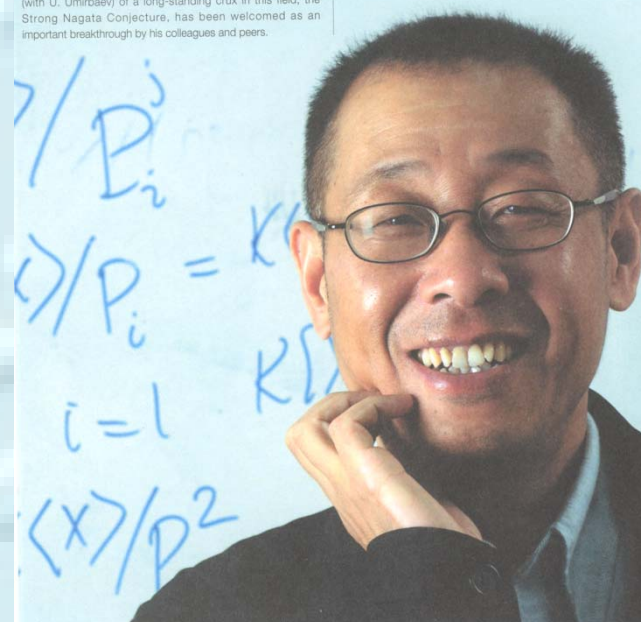
## Dr Yu Jietai

Associate Professor, Department of Mathematics

Dr Yu's area of interest is Affine Algebraic Geometry and Computational Algebra. This is an important and flourishing area of research. At one level, it involves purely mathematical problems such as the famous Jacobian Conjecture, but it also has a strong Computer Science component. Dr Yu has recently done some important work which has established him as a leading figure in this area. In particular, his recent resolution (with U. Umirbaev) of a long-standing crux in this field, the Strong Nagata Conjecture, has been welcomed as an important breakthrough by his colleagues and peers.

Five years ago Dr Yu established the very successful Combinatorial and Computational Algebra Research Programme at this University. Since its inception the programme has attracted distinguished mathematicians from all over the world.

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<http://www.hku.hk/math/>



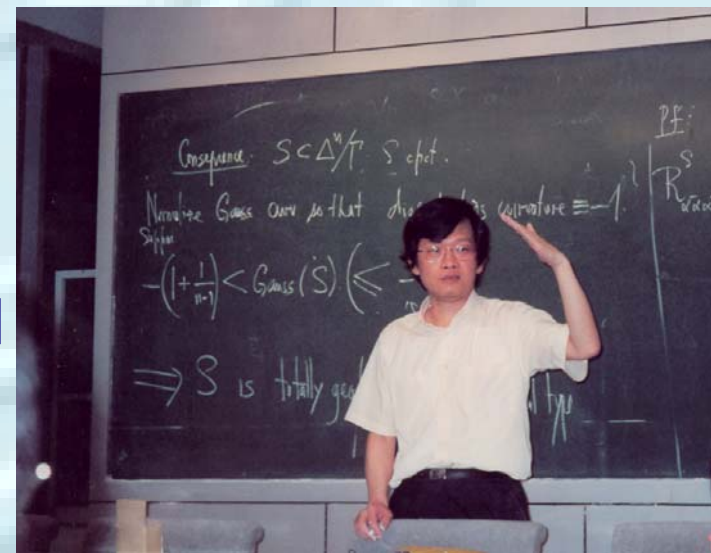
# MATH 3401 Analysis I

- Study basic properties of metric spaces: openness; closedness; accumulation point; boundary point; compactness; completeness; continuity; connectedness, etc. Prerequisite of almost all pure mathematics courses.
- Teacher: Prof. W.S. Cheung (*Harvard*)



# MATH3403 Functions of a Complex Variable

- Do calculus on the complex plane.
- Study of “differentiable” functions of a complex variable which have many nice and interesting properties.
- Useful to the studies of almost all branches of pure mathematics and theoretical physics like quantum mechanics.
- Teacher: Prof. N. Mok (*Stanford*)



# *Major in Mathematics*

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- **Mathematics, Economics and Finance**

# *Pure Mathematics*

## **Recommended courses:**

**MATH3303 Matrix Theory and its Applications**

**MATH3304 Introduction to Number Theory**

**MATH4402 Analysis II**

**MATH3302 Algebra II**

**MATH4404 Functional Analysis**

**MATH4501 Geometry**

**MATH4511 Introduction to Differentiable Manifolds**

**MATH4406 Introduction to Partial Differential  
Equations**

**MATH6101 Intermediate Complex Analysis**

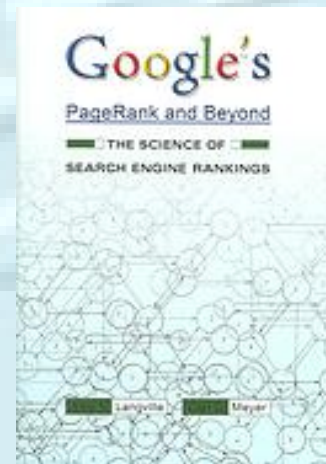
**MATH6504 Geometric Topology**

# MATH 3303 Matrix theory and Its Applications

- Second course in Linear Algebra
- Useful to MATH3601 Numerical Analysis, MATH4602 Scientific Computing and Operation Research courses
- Related to MATH4404 Functional Analysis
- Teacher: Dr. YK Lau (HKU)

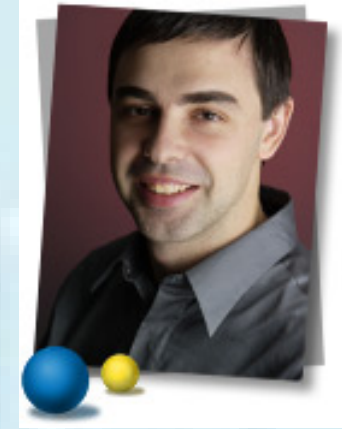


- Matrix theory is extremely useful in the studies of applied and pure mathematics, statistics, economics, finance, engineering, etc.
- For example, it is used in **image processing** and **search engines** like Google.
- See the book, *Google's PageRank and beyond : the science of search engine rankings* by Amy N. Langville and Carl D. Meyer.





Larry Page



Sergey Brin

“The heart of our software is **PageRank™**, a system for ranking web pages developed by our founders **Larry Page** and **Sergey Brin** at Stanford University.”

**Page, Brin, Motwani, Winograd, The PageRank Citation Ranking: Bringing Order to the Web. Stanford Digital Library Technologies Project, 1998.**

# MATH4402 Analysis II

- Comprehensive and rigorous treatment of calculus in several variables, and a modern treatment of integration theory in the language of differential forms which is essential for more advanced studies in analysis and geometry.
- Useful to the studies of Differential and Algebraic Geometry and General Relativity, etc.
- Pass in MATH3401 Analysis I
- Teacher: Dr. PW Wong (*Columbia*)

## *Fundamental Theorem of Calculus (FTC)*

The one-variable fundamental theorem:

$$\int_a^b f'(x) dx = f(b) - f(a).$$

**Main goal:** Generalize FTC to Stokes' theorem for manifolds:

$$\iint_M \text{curl } \mathbf{F} \cdot \mathbf{n} d\sigma = \int_{\partial M} \mathbf{F} \cdot d\mathbf{x}$$

# MATH4501 Geometry

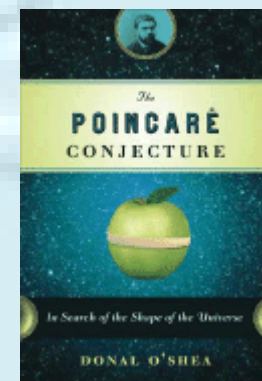
- Use multi-variable calculus to study geometry of curves and surfaces in 3-space.
- Useful to the studies of Differential and Algebraic Geometry and General Relativity, etc.
- Teacher: Dr. PW Wong (*Columbia*)

# MATH4511 Introduction to differentiable manifolds

- Review of calculus in several variables.
- Do calculus on **manifolds** (“higher dimensional surface”).
- Useful to the studies of Differential and Algebraic Geometry and General Relativity, etc.
- Pass in MATH4402 Analysis II and MATH4501 Geometry, or already enrolled in these courses
- Teacher: Dr. PW Wong (*Columbia*)

# MATH6504 Geometric Topology

- This course gives a geometric introduction to some of the methods of algebraic topology. Use algebraic tools to study and classify topological spaces
- Useful to the studies of Differential and Algebraic Geometry and General Relativity, etc.
- For recent important breakthrough in topology, see the book “The Poincaré conjecture: in search of the shape of the universe” by Donal O'Shea.
- Pass in (MATH1101 and MATH1102 and MATH1201 and MATH1202 and MATH2301 and MATH2401) or (MATH1111 and MATH1211 and MATH2201 and MATH2301 and MATH2401)
- Teacher: Dr Z Hua (*Wisconsin*)



## **MATH3304 Introduction to number theory**

- Basic concepts about numbers, their properties and the arithmetic of congruence.
- The interplay between the multiplicative and additive properties of prime numbers
- Properties and the distribution of the prime numbers.
- Important applications of number theory to modern cryptography
- Pass in MATH3301 Algebra I, or already enrolled in this course.



# *Introduction to Number Theory*

Dr. YK Lau  
(*HKU*)

Expert in  
modular forms  
and L-functions



Prof. K.M. Tsang  
(*Princeton*)

Expert in  
Riemann's zeta  
function and  
analytic number  
theory.



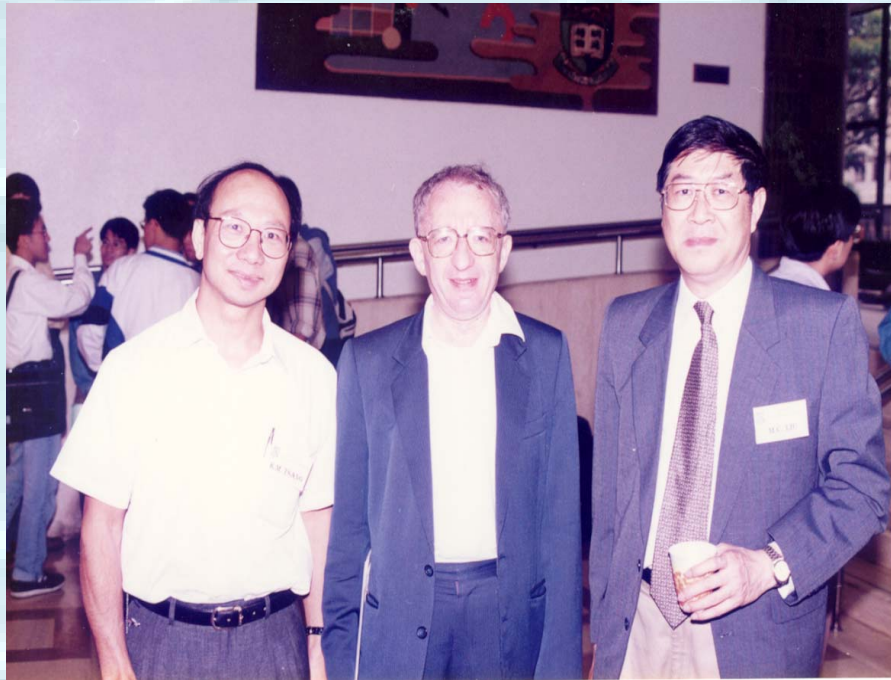
**Dr. B. Kane**

Number theory and  
combinatorics, in  
particular, modular  
and automorphic  
forms

Student of Prof.  
Atle Selberg (1950  
Fields-Medallist)

# Long tradition of number theory in our department

Dr. K.M. Tsang



Prof. M.C.Liu

World expert  
in Goldbach's  
conjecture

Fields-Medallist, Prof. Alan Baker

Public Lecture on Prime Numbers on 15 Feb, 2014 !

# *Computational Mathematics, Operations Research*

## Recommended courses:

**MATH3303 Matrix Theory and Its Applications**

**MATH3601 Numerical Analysis**

**MATH3603 Probability Theory**

**MATH3901 Operations Research I**

**MATH3904 Introduction to Optimization**

**MATH3905 Queuing Theory and Simulation**

**MATH3911 Game Theory and Strategy -**

**MATH4602 Scientific Computing**

**MATH4902 Operations Research II**

**MATH4903 Network Models in Operations Research**

**BUSI1003 Introduction to Management Information System**

**COMP1117 Computer Programming**

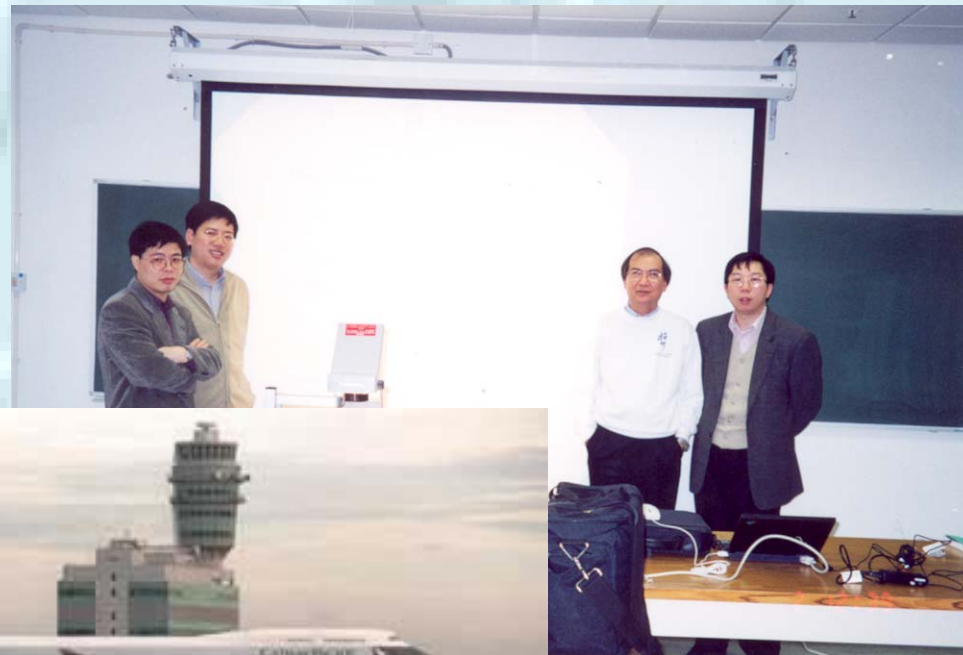
**COMP2119 Introduction to Data Structures and Algorithms**

**ECON0701 Introductory Econometrics**

**STAT4601 Time-series Analysis**

# *Operations Research Group*

**Prof. S.C.K. Chu, Dr.W.K. Ching,  
Prof.W.Zang**



**HSBC** 

# *Computational Mathematics, Operations Research*

- Courses in Computational Mathematics and Operations Research are taught by experts in these two areas.
- For operations research:
  - Prof. S.C.K. Chu (*Columbia*)
  - Dr. W.K. Ching (*CUHK*)
  - Prof. W. Zhang (*Rutgers*)
- For computational mathematics:
  - Dr. K.H. Chan (*CUHK*)
  - Dr. G.Y. Han (*Notre Dame*)

The operations research courses mainly study different types of the constraint optimization problems.

# Main problem: Optimization with constraints

- Max/Min  $f(x_1, \dots, x_n)$  under the constraints  $g_i(x_1, \dots, x_n) = 0, i = 1, \dots, m$ .
- OR I and II study this optimization problem when all functions are linear.
- IO studies the same optimization problem when some of these functions are **non-linear** by using multi-variable calculus.
- Some numerical methods are needed to solve the problems.

# *Mathematics, Economics and Finance*

**Recommended courses:**

**MATH3906 Financial Calculus**

**MATH4907 Numerical Methods for Financial Calculus**

**BUSI1002 Introduction to Accounting**

**ECON2210 Microeconomics Theory**

**ECON2220 Macroeconomics Theory**

**FINA2802 Investments and Portfolio Analysis**

**ECON0701 Introductory Econometrics**

*Major in Mathematics*

*Minor in Economics or*

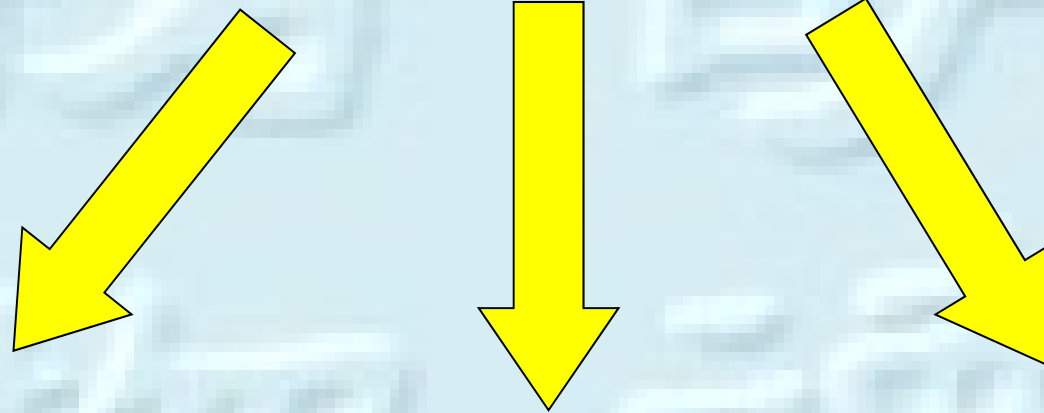
*Finance or Risk*

*Management !*



**Students can  
prepare the level I  
examination of  
Chartered Financial  
Analyst by taking  
suitable courses in  
this category.**

*Major in Mathematics,  
Minor in /Economics / Finance /Risk Management*



Master / PhD: Economics

Finance

Risk  
Management

*Mathematics is the common language in these areas  
and it is easier to learn math when you are young.*



# Mathematics, Economics and Finance

**Nobel Prize in Economics:** Out of the 43 Laureates of the past 22 years,

19 have degrees in mathematics:



- 2007 Eric S. Maskin (BS in math)
- 2005 Robert J. Aumann (BS, MS, PhD in math)
- 2004 Edward C. Prescott (BA in math, MS in OR)
- 2003 Clive W. J. Granger (BA in math)
- 2002 Daniel Kahneman (BA in math and psychology)
- 2001 Michael Spence (BA, MA in math)
- 2000 James J. Heckman (BA in math)
- 1998 Amartya Sen (BA minor in math)
- 1997 Robert C. Merton (BS, MS in applied math)
- 1996 James A. Mirrlees (MA in math)
- 1996 William Vickrey (BS in math)
- 1994 **John F. Nash Jr.** (PhD in math)
- 1994 Reinhard Selten (PhD in math)
- 1992 Gary S. Becker (BA in math)



**MATH 3911 Game Theory and Strategy**

- 2013 Lars Peter Hansen (BS in math)
- 2012 Lloyd Shapley (BA, PhD in math)
- 2012 Alvin E. Roth (BS, MS, PhD in OR)
- 2011 Christopher A. Sims (BA in math)
- 2010 Peter A. Diamond (BA in math)

# *Major in Mathematics – Economics/Finance*

Luo Guannan and Jian Bo (both math major) are now doing a PhD in Economics at Northwestern University and University of Chicago respectively.

If you plan to do a master or PhD in economics or finance, the following courses are recommended:

MATH3401 Analysis I

MATH3901/3902 OR I and II

MATH3904 Introduction to Optimization

MATH3911 Game Theory and Strategy

MATH3906 Financial Calculus

MATH4907 Numerical Methods for Financial Calculus

STAT4601 Time-series Analysis

STAT6010 Advanced Probability

**Many investment banks employ mathematicians to do risk management or computational finance**



**Dr. Lau Chi Fong (PhD in number theory)**

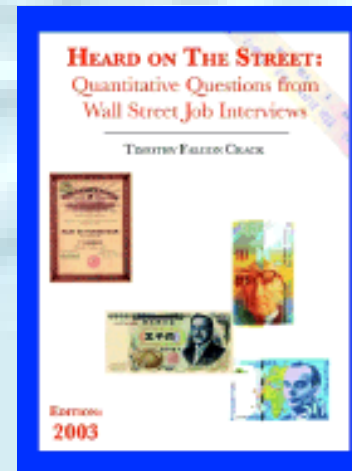
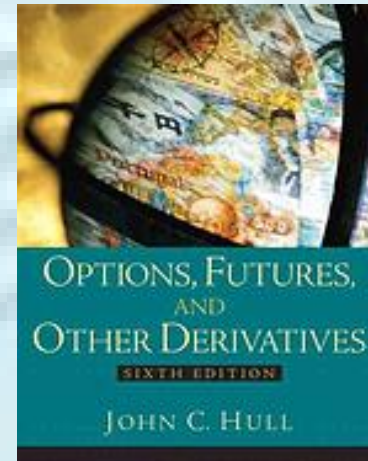
**Former Head of Market Risk Management, HSBC Global Markets**

# Computational/Quantitative Finance

- Usually need a PhD in Mathematics/Physics/Computer Sciences/Statistics to do quantitative finance in investment banks.
- Develop and analyze new financial products.
- Write programs to evaluate the price of financial derivatives.
- Mathematical modeling skill.
- Computing skills, e.g., Visual Basic.

# To learn more about quantitative finance, can read the following books

- **Options, futures, and other derivatives / John C. Hull**
- **An Elementary Introduction to Mathematical Finance/ Sheldon M**
- **Heard on the street : quantitative questions from Wall Street job interviews / Timothy Falcon Crack.**



# Computational Finance

- **MATH3906 Financial Calculus**
- **MATH4907 Numerical Methods for Financial Calculus**
- MATH3603 Probability Theory
- MATH3601 Numerical Analysis
- MATH4602 Scientific Computing
- MATH4406 Introduction to PDEs
- **STAT4601 Time-series Analysis**
- **STAT6010 Advanced Probability**

# MATH3906 Financial Calculus

- Modeling of financial derivatives, asset pricing and market risks
- Introduction to stochastic calculus
- Provide a solid background for future study in quantitative finance.
- Prerequisite: MATH3603 Probability Theory
- Good knowledge of partial differential equations and probability theory is needed for further studies.
- Teacher: Dr. S.P. Yung (*Wisconsin*)

# *Major in Mathematics (requirement)*

## **3. Capstone Requirement (6 credits)\***

At least 6 credits selected from the following courses:

MATH4002 Senior Mathematics Seminar (6 credit)

**MATH4988 Mathematics Internship (6 credits)**

MATH4989 Mathematics Capstone Project (6 credit)

**MATH4999 Mathematics Project (12 credits)**

Students are not required to take Capstone if this Science major is taken as a second major on the condition that the capstone experience in the first major requires the integration or application of knowledge from both major disciplines.

If this is approved, a 6 – credit advanced level course in the second major must be taken to fulfill the credit requirement of the capstone experience.



# *MATH4988 Mathematics Internship*

This course aims to offer students the opportunities to gain work experience in the industry related to their major of study.

Students have to take on at least **160 hours** of internship work either within the University or outside the University arranged by the department.

Details of internship will be recorded on the student's transcript.

Available in 1st, 2nd, and the summer semester.

**Pre-requisites:** Students are expected to have satisfactorily completed their Year 3 study.

**Assessment:** Required to submit a written report and to give an oral presentation on their internship experience. This course will be assessed on **Pass or Fail** basis.

# *MATH4988 Mathematics Internship*

In the past years, our students interned at various organizations:  
for example

- **AECOM:** A Fortune 500 company, serves clients in more than 100 countries and provides professional technical and management support services to a broad range of markets, including transportation, facilities, environmental and energy.
- Hong Kong Observatory
- HKEx OTC Clearing Risk Management
- Education Bureau of HKSAR
- **NITTAN CAPITAL ASIA LIMITED**
- Times Publishing (HK) Limited
- Pearson Education Asia Limited
- Secondary schools
- Our teachers also offered internship in the summer.

## *MATH4988 Mathematics Internship*

- Usually, we will inform our students the internship opportunities around May and inform the students the results around June.
- You can also find a summer internship through CEDARS.
- After the completion of the project, you need to do a 10-15 minute oral presentation about your internship.
- Finally, need to submit a written report of at least 1000 words on what has been done and what has been learnt during the internship.

# *MATH4999 Mathematics Projects*

The aim of the course is to provide students with opportunity to formulate and investigate, in depth, problems of practical interest and/or have a foretaste of mathematical research.

The work, to be done on an individual basis, is considered a highly desirable part of the training of a mathematician.

Pre-requisites: MATH3301 (Algebra I) and  
MATH3401 (Analysis I)

# *MATH4999 Mathematics Projects*

## Topics:

- Arithmetical Functions and Dirichlet Series
- Calculus of Variations
- Dirichlet's Divisor Problem
- Higher Rank Numerical Ranges
- Introduction to Algebraic Geometry
- Isoclinic  $n$  – planes in Euclidean  $2n$  – space
- Mathematical Problems in Network Coding
- Numerical Simulation in Fluid Dynamics
- On Construction and Control of Probabilistic Boolean Networks
- Open problems in affine algebraic geometry and commutative/noncommutative algebra
- Perron – Frobenius Theory of Nonnegative Matrices
- Project Scheduling via Network Models: independent study & computer implementation
- Solving Non-Linear Differential Equations
- Statistical Arbitrage Strategies in Equity Market
- Supersymmetric Quantum Mechanics and the Witten Index

# *MATH4999 Mathematics Projects*

- Usually, we will inform our students the project topics around June/July and inform the students the results around July/August.
- This is a 12 credit course and students must achieve good standing and get the approval from both the prospective supervisor and the course co-ordinator to take this course.
- The student is expected to do approximately 200 hours of independent work and to attend meetings and seminars.
- **Assessment Method:** By dissertation (70% weighting) and continuous assessment which may include oral presentation (30% weighting)

# *MATH4002 Senior Mathematics Seminar*

- This is a seminar style course intended for students who have very strong interests and good ability in mathematics and have inclination to mathematical research.
- Students will look at particular mathematical topics in depth, and will master the topics through reading, listening, discussing and writing
- Active participation in all the discussions is expected. The aim of the course is to let students learn how to initiate self/independent study in mathematics.
- Prerequisite is at least 24 credits of advanced level Mathematics courses (MATH3xxx, MATH4xxx, or MATH6xxx), including MATH3301 Algebra I, MATH3401 Analysis I, and MATH3403 Functions of a Complex Variable.
- Research report(50%), Dissertation(20%), Oral presentation(30%)

# *MATH4989 Mathematics Capstone Projects*

Students will work collaboratively in small groups on a project that requires integration or application of knowledge they have acquired.

The project topic is not limited to academic context, but can also be extended to a community or corporate outreach project.

Projects may take the form of a combination of literature research, survey, data analysis, creation of artifacts or media contents, exhibition, public lectures, etc.

Prerequisite is at least 24 credits of any advanced level Mathematics courses (MATH3xxx, MATH4xxx, MATH6xxx).

Research report(50%) , Dissertation(20%), Oral presentation(30%)

Topics of MATH4002 and MATH4989 will be announced to students after the May examination.

Enrollment in the courses requires approval by the Department.



## *Further Enquiries : Course selection Advisers*

Dr. C.W. Wong (cwwongab@hkusua.hku.hk)

Dr. G. Han (ghan@maths.hku.hk)

Dr. P.W. Wong (ppwong@maths.hku.hk)

Dr. S. Wu (swu@maths.hku.hk)

Dr. K.H. Law (lawkaho@maths.hku.hk)

[http://hkumath.hku.hk/web/info/math\\_student.html](http://hkumath.hku.hk/web/info/math_student.html)

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