FACULTY OF SCIENCE
THE UNIVERSITY OF HONG KONG
香港大學理學院

Master of Science in the field of PHYSICS

Incubating talent pool of well-versed cadres in physics

2024-25 (September 2024 intake)

IS THE PROGRAMME FOR YOU

Why this Programme

- An innovative and well-designed MSc programme that strengthens students' background to cope with ever-evolving challenges
- Stresses a balanced and flexible approach, with a strong focus on catering to the academic and career aspiration of students, developing their own specialty in subject knowledge and technical skills

World-class Rankings of HKU

Quacquarelli Symonds (QS) QS WORLD UNIVERSITY RANKINGS

#26 *World Rankings 2024*

#4 *Asia Rankings 2023*

Times Higher Education (THE) THE World University Rankings

#31 *World Rankings 2023*

#4 *Asia Rankings 2023*

Eminent Subject Ranking QS WORLD UNIVERSITY RANKINGS

QS World University Rankings by Subject 2022:

#67 Physics & Astronomy

Top-notch Scientists in the Faculty

Clarivate Analytics' Essential Science Indicators

18% *of our professoriate staff (average over the past decade) are classified Top 1% scholars*

What the Programme Covers

Provides a flexible yet solid education on theories, techniques and frontier developments in different subfields in physics including the following fields of specialisation:

- ◊ astrophysics
- ◊ device and nanophysics
- ◊ computational physics
- ◊ photonics and quantum information
- ◊ condensed matter physics

Tuition fees
Composition fee: HK$180,000# (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 year

Study load
Credits: 60 credits
Learning hours: about 1,200 – 1,400 hours (including 180 hours for project and 310 – 360 contact hours)

Class schedule
Teaching could be on weekdays or weekday evenings, with occasional concentrated teaching during weekends

Medium of Instruction
English

Assessment
Mostly coursework and written examination

 # The fee shall generally be payable in 2 instalments over 1 year

Where will this Programme Lead You

Transferable skills

- ◊ The problem-solving skills, in particular with quantitative and analytical techniques, bode well for all graduates with a formal physics training

Career development

- ◊ Master degree holders in physics with advanced preparation in mathematics, laboratory skills, and programming are highly valued by many employers, allowing these graduates to enter the job market through multiple channels
- ◊ Prepares quality physicists for the high-technology workplace

Host

Department of Physics

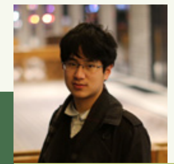
The Department of Physics conducts research at the cutting edge of fundamental and applied physics. The overarching research vision of the Department is to become locally pre-eminent, leading in Asia, and globally competitive in selected sub-fields of research. Our researchers engage in frontier research in the fields of Astronomy and Astrophysics; Computational Physics; Theoretical and Experimental Condensed Matter Physics; Materials Sciences; Nuclear and Particle Physics; Photonics and Quantum Information. We also incorporate advanced research in teaching and offer a number of postgraduate projects to nurture well-versed individuals.

Who should Take this Programme

Students who intend to pursue another master or doctoral degree in a wide range of science or engineering disciplines in the future

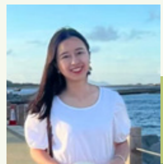
Students who would like to enhance their competitiveness in high-tech industry

Hear from our graduates



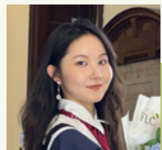
Zhou Kaixuan
Class of 2023

"I was a mathematics student who got basic physics background before entering the MSc Physics programme. But in this one-year-long programme, my capstone project supervisor really trained me how to think and work as a physicist. The well-designed courses really enriched my understanding of physics and helped me get ready for my coming PhD studying photonics in NYU. Generally speaking, this programme is definitely not an easy one, but you will gain a lot after this challenging year."



Zhu Yijun
Class of 2023

"I have learned a lot from the physics master's programme. The Department offers us a variety of courses, covering astrophysics, theoretical physics, condensed matter physics, etc. Here I can choose any course I like, and the Professor's serious attitude toward teaching is very impressive. At the same time, the Department also sets up the capstone project for each student. We can freely choose topics of interest to participate in research. I am very grateful for everything I have learned at HKU, and thanks all the Professors who helped me in the Department of Physics. The experience of HKU inspires me to constantly break through myself in the future!"



Li Tianyi
Class of 2023

"It was not a long study year, but I benefited a lot. The course arrangement of the Department is very thoughtful. For example, the regular physics seminars allowed us to learn about the latest scientific research progress in related fields and broaden our horizons. Also, the capstone project allowed us to choose from different research directions according to our interests. Under the supervisor's guidance, I could fully realise my potential and develop the ability to solve seemingly impossible problems. In addition to academic improvement and career inspiration, I got to know many excellent teachers and classmates; they gave me great support and encouragement which I will never forget. I have been working as an EDA product engineer in Empyrean after graduation."

Programme structure

Design of curriculum (60 credits)	
Compulsory courses (9 credits)	
PHYS8201 Basic research methods in physical science *(6 credits)* PHYS8970 Physics seminar *(3 credits)*	
Disciplinary elective courses (42 credits) Take at least 42 credits from Lists A and B with at least 18 credits must be chosen from List A:	
List A PHYS8150 Computational physics and its contemporary applications *(6 credits)* PHYS8351 Graduate quantum mechanics *(6 credits)* PHYS8450 Graduate electromagnetic field theory *(6 credits)* PHYS8550 Graduate statistical mechanics *(6 credits)* PHYS8701 Physics experimental techniques *(6 credits)*	List B PHYS8352 Quantum information *(6 credits)* PHYS8551 Topics in solid state physics *(6 credits)* PHYS8552 Condensed matter physics *(6 credits)* PHYS8654 General relativity *(6 credits)* PHYS8656 Topics in astrophysics *(6 credits)* PHYS8750 Nanophysics *(6 credits)* PHYS8751 Device physics *(6 credits)* PHYS8850 Topics in particle physics *(6 credits)* PHYS8852 Photonics and metamaterials *(6 credits)* PHYS8152 Data analysis in physics, astronomy and space science *(6 credits)* PHYS8153 Big data, AI and machine learning in physics, astronomy and space science *(6 credits)*
Capstone requirement (9 credits)	
PHYS8971 Capstone project *(9 credits)*	

Remarks: The programme structure will be reviewed from time to time and is subject to change.

Compulsory Courses

PHYS8201 Basic research methods in physical science

This course introduces basic research methods commonly used in various sub-fields in physics. It comprises of four modules, each introduces commonly used research methods in physics. Students are required to take two out of the four modules. They are 1. Astrophysical techniques: Commonly used techniques and packages in astrophysical data gathering and data analysis are introduced. 2. Computational physics and modelling techniques: Commonly used computational physics and physical modelling methods are introduced. 3. Experimental physics techniques: Commonly used experimental physics apparatus and techniques are introduced. 4. Theoretical physics: Commonly used techniques in mathematical and theoretical physics are introduced.

PHYS8970 Physics seminar

This course aims to initiate students into research culture and to develop a capacity for communication with an audience of varied backgrounds. Students attend and take part in a specified number of colloquia and seminars organised by the Department of Physics to expose themselves to various topics of contemporary physics research and to learn the technique of professional physics presentations. Students are required to give an oral presentation, normally on materials related to their Capstone Project. Students are also required to submit assignments based on the colloquia attended to receive a pass in this course.

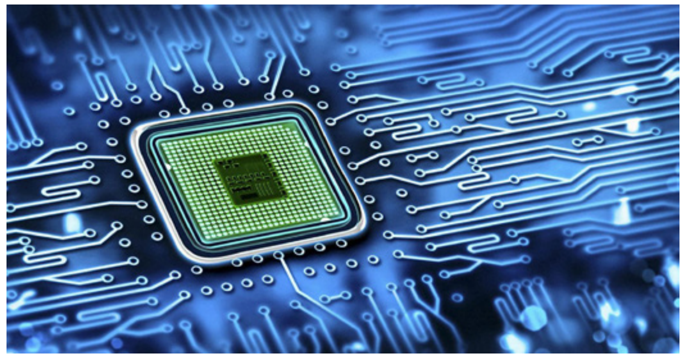
Disciplinary Elective Courses

PHYS8150 Computational physics and its contemporary applications

This course shows the power of computational approach to solving physics and related problems, which is complimentary to the traditional experimental and theoretical approaches. Students are expected to spend a significant fraction of time in actual programming. Topics include: Introduction to computational physics; ordinary differential equation for classical physical problems; partial differential equation for classical and quantum problems; matrix method and exactly diagonalisation for classical and quantum problems; Monte Carlo methods for statistical physics and quantum many-body physics; numerical methods for phase transitions and machine learning approaches to physics problems.

PHYS8351 Graduate quantum mechanics

This course introduces postgraduates to the theory and advanced techniques in quantum mechanics, and their applications to selected topics in condensed matter physics. The course covers the following topics: Dirac notation; quantum dynamics; the second quantisation; symmetry and conservation laws; permutation symmetry and identical particles; perturbation and scattering theory; introduction of relativistic quantum mechanics.



PHYS8450 Graduate electromagnetic field theory

The aim of this course is to provide students with the advanced level of comprehending on the theory of classic electromagnetic field, enabling them to master key analytical tools for solving real physics problems. This course introduces and discusses the following topics: Boundary-value problems in electrostatics and Green's Function method; electrostatics of media; magnetostatics; Maxwell's equations and conservation laws; gauge transformations; electromagnetic waves and wave guides.

PHYS8550 Graduate statistical mechanics

This course covers advanced topics in equilibrium statistical physics. Topics include: Ensemble theory; theory of simple gases, ideal Bose systems, ideal Fermi systems; statistical mechanics of interacting systems; statistical field theory; some topics in the theory of phase transition may be selected.

PHYS8701 Physics experimental techniques

This course provides a detailed account of some common experimental techniques in physics research. It introduces the basic working principles, the operational knowhow, and the strength and limitations of the techniques. It will discuss and train students of the following techniques:

1. Noise and data analysis
2. Computer grid
3. Raman spectroscopy and photoluminescence
4. Temporal characterisation of ultrashort laser pulses
5. Chirped pulse amplification - technique to amplify laser pulses
6. Cryogenics and low-noise electrical measurements
7. Nanofabrication techniques
8. Free-electron nanophotonics
9. Scanning probe microscopy
10. Electron and X-Ray diffraction
11. Photoemission spectroscopy
12. Transmission electron microscopy
13. Radiation detection and measurements in nuclear physics

PHYS8352 Quantum information

This course covers the theory of quantum information and computation and its applications in physics and computer science. Topics include: Quantum computer; quantum algorithms; quantum error correction; quantum information processing; quantum entanglement and quantum cryptograph.

PHYS8551 Topics in solid state physics

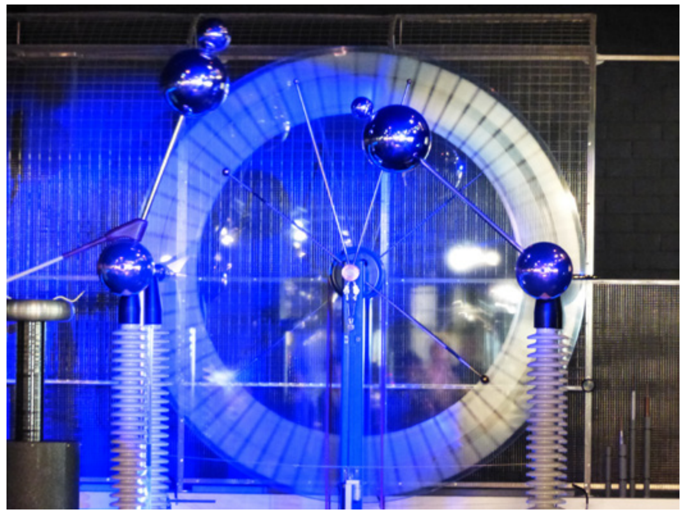
This course covers a broad introduction to modern theory of the solid state physics. Some selected advanced topics will also be discussed. Topics include: Crystal structures and symmetry; the reciprocal lattice and X-ray diffraction; lattice vibration and thermal properties; free electron of metals; band structures and Bloch theory; nearly free electrons and tight binding approximations; semiclassical model of electron dynamics; Boltzmann equation; transport and optical properties of metals and semiconductors; interaction and collective excitations. If time permits, magnetism and superconductivity will also be covered.

PHYS8552 Condensed matter physics

This course introduces many-body physics in quantum matter. Systems consisting of many particles (bosons or fermions) display novel collective phenomena that individual particles do not have, for example, ferromagnetism and superfluidity. It aims to introduce students the general principles behind these phenomena, such as elementary excitations, spontaneous symmetry breaking, adiabatic theorems, emergent topological phases of matter, etc. Theoretical language useful in the interpretation of experiments, such as linear response theory and response functions, will be discussed. This course will focus on the phenomena of emergent many-body states that require not only the effect of quantum statistics but also that of inter-particle interaction. Examples include: Ferro-magnetism, Fermi liquid, superfluidity, superconductivity, and the quantum Hall states. Some general themes related to these quantum states, such as elementary excitation, Ginzburg-Landau description, spontaneous symmetry breaking, and topological phases of matter will be discussed. This course is intended for both experimentalists and theorists. While there are no official prerequisites, students who would like to take this course are assumed to have sufficient knowledge on quantum mechanics and statistical mechanics.

PHYS8654 General relativity

This course serves as a graduate level introduction to general relativity. It provides conceptual skills and analytical tools necessary for astrophysical and cosmological applications of the theory. Topics include: The principle of equivalence; inertial observers in a curved space-time; vectors and tensors; parallel transport and covariant differentiation; the Riemann tensor; the stress-energy tensor; the Einstein gravitational field equations; the Schwarzschild solution; black holes; gravitational waves detected by LIGO, and Freidmann equation.



PHYS8656 Topics in astrophysics

This course covers high energy processes, basic theory of stellar structure and evolution, and introduction to compact objects. It follows a vigorous mathematical treatment that stresses the underlying physical processes. Topics include: Radiation mechanisms; stellar structure equations; polytropic model; elementary stellar radiation processes; simple stellar nuclear processes; stellar formation; late stage of stellar evolution; supernova explosion; compact stellar; cosmic rays; numerical solving of stellar structure equation; if time permits, additional selected topics will be covered.

PHYS8750 Nanophysics

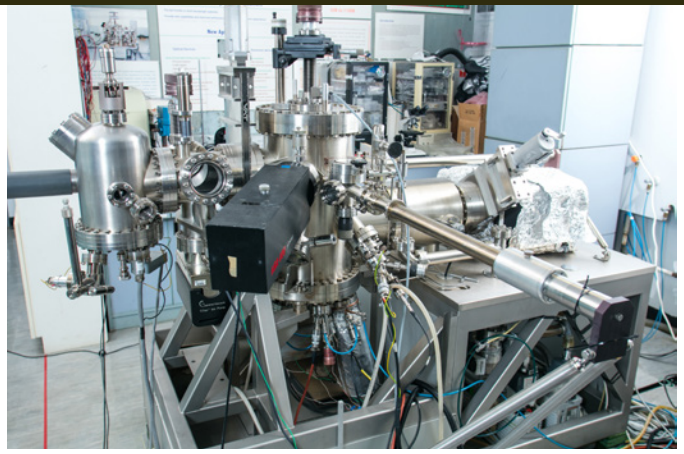
This course is designed to deliver fundamental concepts and principles of nano physics to fresh postgraduate students, mostly focusing on the transport properties of the low-dimensional electronic systems under external electric and/or magnetic fields. It will cover various topics in nano physics, such as zero-, one-, and two-dimensional electronic gas systems, quantum dots, graphene and 2D materials, semiconductor heterostructures, quantum Hall effects, Coulomb blockade effects, single electron effects, field effect transistors, phase-coherent interference effects, and more. While most discussions will be made based on experimental findings, the basics of the relevant theories will also be covered using the tight-binding model, basic quantum mechanics, and Landauer-Büttiker formula. The principles and applications of nano fabrication and low-temperature measurement techniques will also be discussed.

PHYS8751 Device physics

The growth in the past 70 years of modern electronics industry has had great impact on society and everyday life, the foundation of which rests upon the semiconductor physics and devices. This course aims at presenting a comprehensive introductory account of the physics and operational principles of some selected

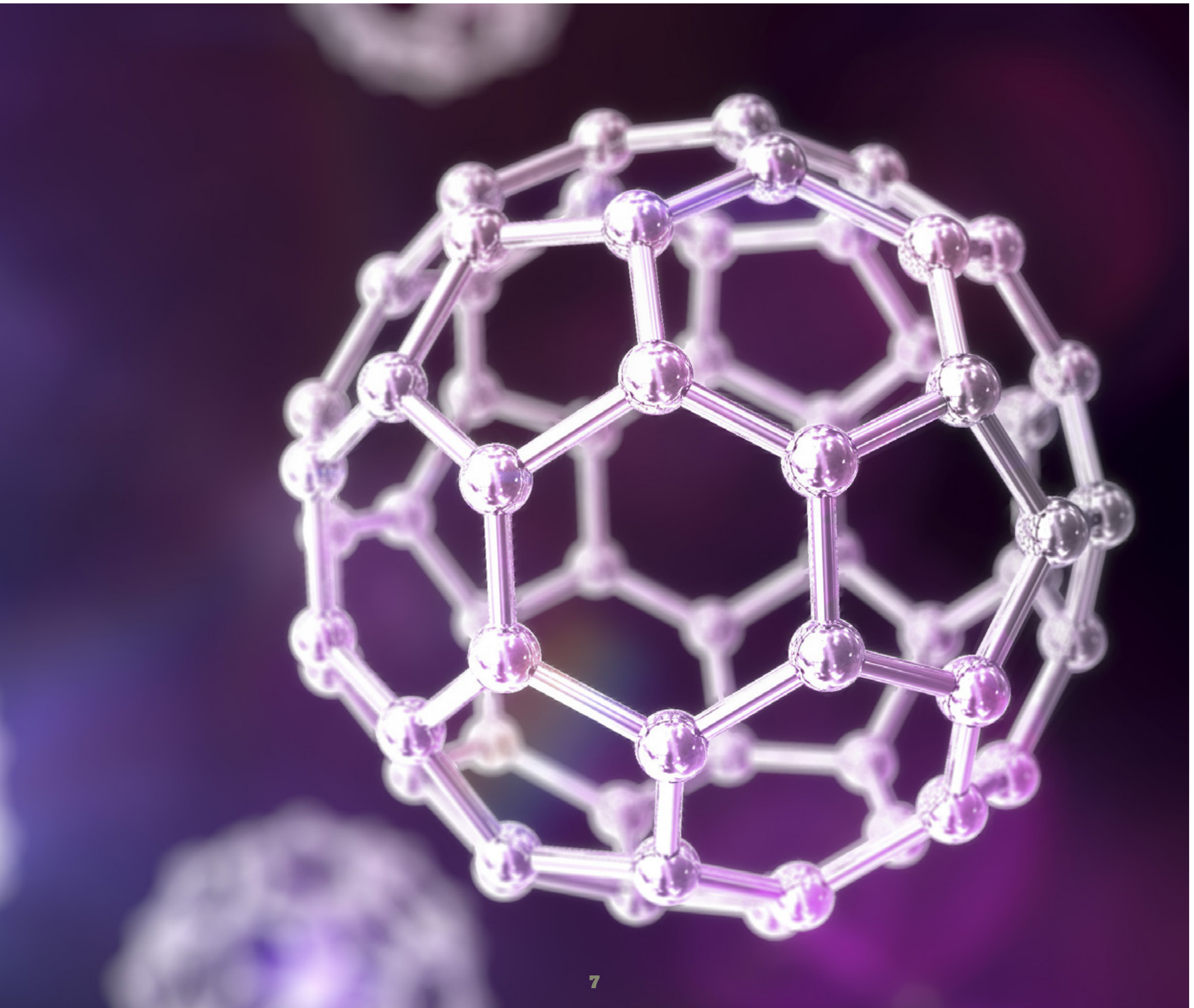
Course Descriptions

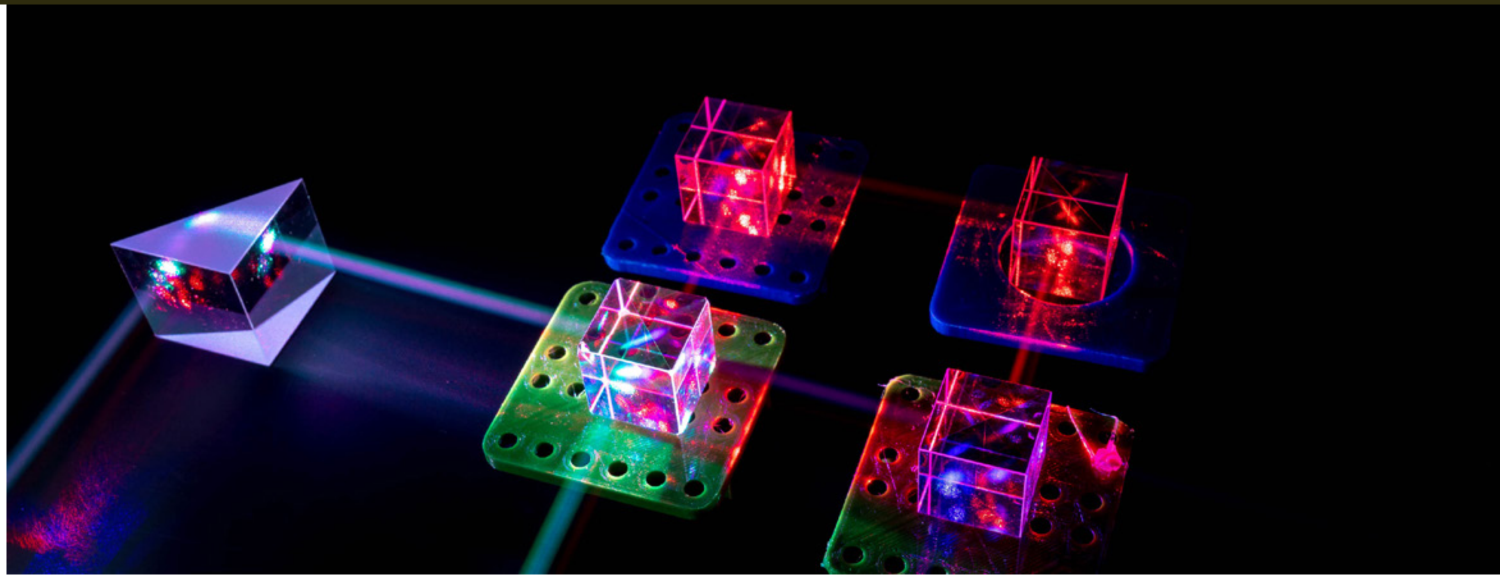
and yet classic semiconductor devices, microelectronic and optoelectronic. The course is primarily designed for postgraduates but can be of interest to senior undergraduates in physics, electrical and electronic engineering and materials science. Students are assumed to have acquired some basic knowledge of quantum mechanics, statistical mechanics, and solid state physics, though a review of the physics of semiconductors will be given in the beginning of the course. This course begins by giving a review of solid state physics, particularly of the physics of semiconductors. It is then followed by discussions of the fundamentals and practical aspects of PN-junctions and rectifying diodes, amplifying and switching devices like bipolar and field-effect transistors (e.g. MOSFET), light-emitting and detection devices such as LEDs, laser diodes, and photodetectors. If time allows, a brief discussion of some special devices will be presented.



PHYS8850 Topics in particle physics

This course covers selected topics in both theoretical and experimental aspects of particle physics. Topics include: Fundamental particles; symmetry and conservation law; Feynman diagrams; electromagnetic interaction; weak interaction; strong interaction; particle accelerator and detector.





PHYS8852 Photonics and metamaterials

In the last two decades, tremendous progress has been made in the manipulation of light propagation using structured photonic media - metamaterials, with negative refraction, super-imaging and invisibility cloaking as the most well-known examples. These new discoveries are paving ways towards many potential applications of photonic structures, including imaging, display, holography and information processing. This course aims at providing the fundamental understanding of the interaction of light with structured media whose unit cells are much smaller than the wavelength of light, and the design and functionalities of various metamaterial based photonic devices. The course text is primarily designed for senior undergraduate students and postgraduate students and requires some knowledge on electromagnetism and optics. On the other hand, it will also be of interest to graduate students since it includes some most recent results in the field of metamaterials and nanophotonics. Topics include: Modeling of interaction of light with periodic structures, gratings, photonic crystals; coupled mode theory; interaction of light with metals, covering both propagating and localized surface plasmon polaritons; effective-medium description of the unconventional electromagnetic properties of metamaterials, such as negative permeability and negative refraction, zero refraction index, hyperbolic metamaterials, chirality and bi-anisotropy; design of the unit cells of the metamaterials based on plasmonic structures for achieving various electromagnetic properties and functionalities; transformation optics and invisibility cloaks; metamaterial devices, including super-imaging lenses, meta-lenses, metasurface holography etc.; nonlinear optical properties of metamaterials and metasurfaces; photonic systems with Parity-time symmetry; metamaterial approach for designing the topological properties for light.

PHYS8152 Data analysis in physics, astronomy and space science

This course introduces concepts of data analysis in physics, astronomy and space science. Techniques ranging from traditional statistical methods to more recent machine learning methods will be introduced. Applications of these techniques in physics, astronomy and space science will be the focus in this course for students to understand how they are deployed in solving actual problems.

PHYS8153 Big data, AI and machine learning in physics, astronomy and space science

Artificial intelligence (AI), Machine Learning and Big Data analytics have found widespread applications in all branches of science and technology. The objective of this course is to introduce concepts of AI and big data analytics, with focus on their applications in physics, astronomy and space science. Selected advanced examples on how big data science and deep learning can be applied in physics, astronomy and space science will be introduced to provide students a flavor of the contemporary research in the field.

Capstone Requirement

PHYS8971 Capstone project

This capstone course provides students with the opportunity to study a specific research-type problem by themselves, either theoretical, experimental or numerical, under the supervision of an academic staff using the knowledge the student gained in their entire MSc study. For theoretical and numerical projects: Students will receive training in research literature reading and reviewing, and make investigation which is close to research work in nature, under the supervision of a staff member. Students may need to perform some original calculations, to fill in mathematical gaps of some sophisticated derivations, or a combination of both. For numerical projects, students also need to use computers to find numerical or simulation results. For experimental projects: Students will carry out experiments in research labs under the supervision of a staff member. Students will receive a comprehensive training in advanced experimental techniques, including preparation of samples, determination of physical properties, measurement of small signals obscured by noise, laser, high-vacuum and low-temperature techniques and so on. Wide reading of the relevant scientific literature and originality in experimental design are expected. It is expected that most of the projects would involve team work.

Pre-requisites: Pass or already enrolled in PHYS8201 and PHYS8970.

More course information at:
https://www.scifac.hku.hk/prospective/tpg/Physics

The Master of Science in Physics programme in the Physics Department, The University of Hong Kong aims to further equip university graduates with physics or related backgrounds for various career pathways. This programme provides students an opportunity to learn a wide range of advanced topics in theoretical, computational and experimental physics via taught courses and a capstone research project. Through the systematic postgraduate training in selective subject areas including astronomy, condensed matter physics, device and nano-physics, photonics and quantum information science, students can deepen and broaden their understanding of physics, and gain transferrable skills for both fundamental research and career prospects. As a top tier cohort in physics research and higher education in Asia, the Physics Department is dedicated to nurturing students to achieve their educational goals and beyond.

Programme Director
Professor Xiaodong CUI
BS *USTC*; PhD *Ariz State*

Other Programme Committee Members

Dr Kai Ming LEE (Co-Programme Director)	BSc *HKU*; PhD *Caltech*
Professor Hoi Fung CHAU	BSc, PhD *HKU*; M *IEEE*; F Inst P
Dr Stephen Chi Yung NG	BSc, MPhil *HKU*; MS, PhD *Stanford*

Other Academic staff

Dr Jane Lixin DAI	BSc *HKUST*; MSc, PhD *Stanford*
Professor Aleksandra B DJURIŠIĆ	BSc(Eng); MSc(Eng); PhD *Belgrade*
Dr Dong-Keun KI	BSc, PhD *POSTECH*
Dr Jenny Hiu Ching LEE	BS *CUHK*; MS, PhD *Michigan State*
Dr Alex Po LEUNG	BSc *CityU*; MPhil *HKU*; PhD *Queen Mary London*
Dr. Jeremy Jin Leong LIM	BSc, PhD *Macquarie*
Dr Francis Chi Chung LING	BSc, MPhil, PhD *HKU*; CPhys; M *IEEE*; F Inst P
Dr Tran Trung LUU	BSc *VNU*; MSc *KAIST*; PhD *LMU*
Professor Zi Yang MENG	BSc *USTC*; PhD *Uni Stuttgart*
Dr Jason Chun Shing PUN	BA, BS *Roch*; MA, PhD *Harvard*
Professor Shunqing SHEN	BSc, MSc PhD *Fudan*
Dr Yanjun TU	BSc *USTC*; PhD *U Penn*
Dr Chenjie WANG	BSc *USTC*; PhD *Brown*
Professor Zidan WANG	BSc *USTC*; MSc, PhD *Nanjing U*
Professor Mao Hai XIE	BEng *Tianjin*; MSc *Chinese Acad of Sc*; PhD *Lond*; DIC
Dr Yi YANG	BSc *Peking*; MSc *Peking*; PhD *MIT*
Professor Wang YAO	BS *Peking*; PhD *UCSD*
Professor Shizhong ZHANG	BS *Tsinghua*; PhD *UIUC*
Professor Shuang ZHANG	BS *Jilin*; MS *Northeastern*; PhD *UNM*

Admissions

Requirements

- ◊ A Bachelor's degree or above (equivalent qualification) in a relevant Science subject (e.g. Physics, Astronomy, Earth Sciences, Mathematics) or an Engineering discipline
- ◊ Prior knowledge in university-level electromagnetism, quantum mechanics and thermodynamics, university-level linear algebra and multi-variable calculus, basic statistics, and some computer programming experience (e.g. coding in C++, Mathematica, Matlab or Python)
- ◊ Shall pass a qualifying examination if deemed necessary
- ◊ Fulfil the University Entrance Requirements

How to apply

Application deadlines:
Non-local applicants: **12:00 noon (GMT +8), April 30, 2024**
Local applicants: **12:00 noon (GMT +8), June 28, 2024**

Online application:
admissions.hku.hk/tpg

Expected degree conferment will take place in

November/December 2025 (Winter Congregation)

Further Information

Programme details

bit.ly/3s6F9Q9

Enquiries

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HKU Science