Oxford Master Course
in
Mathematical and Theoretical Physics

http://mmathphys.physics.ox.ac.uk

Department of Physics/Theoretical Physics

Mathematical Institute

Information event for year three
MPhys, MMath and MPhysPhil students

What is it?

A high-level master course in Mathematical and Theoretical Physics which you can pursue in your fourth year instead of following the fourth year of the MPhys/MMath/MPhysPhil.

Meant to take you up to research level in Mathematics/Physics.

The four main areas covered by the course are:

- Quantum Field Theory, Particle Physics and String Theory
- Theoretical Condensed Matter Physics
- Theoretical Astrophysics, Plasma Physics and Physics of Continuous Media
- Mathematical Foundations of Theoretical Physics

Overview of Lecture Courses			
	Theoretical Particle Physics	*Theoretical Condensed Matter Physics*	*Theor. Astrophysics, Plasma Physics & Physics of Continuous Media*
MT	**Quantum Field Theory** (24)		
		Advanced Quantum Theory$^{(PU:C6)}$ (16)	
	Topological Quantum Theory (16)		
		Kinetic Theory (28)	
			Rad. Proc. & High Energy Astro. (20)
			Quantum Processes in Hot Plasma (12)
	Gen. Relativity I$^{(MU:C7.5)}$ (16)	⇐ ⇒	**Gen. Relativity I**$^{(MU:C7.5)}$ (16)
	Perturbation Methods$^{(MU:C5.5)}$ **(16)**		
	Numerical Linear Algebra$^{(MU:C6.1)}$ (16)		
	Groups and Representations (24)		
	Algebraic Topology$^{(MU:C3.1)}$ *(16)*		
	Differential Geometry $^{(MU:C3.3)}$ (16)	⇐ ⇒	Differential Geometry $^{(MU:C3.3)}$ (16)
	Advanced Philosophy of Physics(16)		
	Algebraic Geometry$^{(MU:C3.4)}$ *(16)*		
HT		Advanced Fluid Dynamics (16)	
		Soft Matter Physics (16)	
		Renormalisation Group (16)	
		Nonequilibrium Statistical Physics(16)	
	Advanced QFT (24)		*High Energy Density Physics(16)*
	String Theory I$^{(MG)}$ *(16)*	*Networks*$^{(MU:C5.4)}$ *(16)*	*Collisionless Plasma Physics (18)*
	Supersymmetry & Sugra (16)		*Galactic & Planetary Dyn. (16)*
	Intro to Quantum Information $^{(MU:C7.4)}$ (16)		
	Gen. Relativity II$^{(MU:C7.6)}$ (16)	⇐ ⇒	Gen. Relativity II$^{(MU:C7.6)}$ (16)
	Cosmology (16)	⇐ ⇒	Cosmology (16)
	Lattice QFT $^{(*)}$ *(8)*		
	Applied Complex Variables$^{(MU:C5.6)}$ (16)		
	Symbolic, Numerical and Graphical Scientific Programming (16)		
	Advanced Philosophy of Physics(16)		
	Geom. Group Th.$^{(MU:C3.2)}$ *(16)*		
TT	Conformal Field Theory $^{(*)}$ (16)		
		Topics in Soft & Active Matter Physics (8)	
	String Theory II$^{(MG,*)}$ *(16)*		
	The Standard Model $^{(*)}$ *(16)*	*Topics in Quant. CMP (8)*	*Collisional Plasma Physics (16)*
	(Aspects of)Beyond the St. Model (16)		
			Disc Accretion in Astrophysics (12)
			Quantum Matter (16)
	QFT in Curved Space$^{(*)}$ (16)	⇐ ⇒	QFT in Curved Space$^{(*)}$ (16)
	Dissertation, replacing one or two 16-hour lecture course		

You can focus on one of the four areas, study across areas and place emphasis on either more physical or more mathematical aspects.

Required are 10 units (1 unit = 16 hour lecture course) which include

a) four units examined by a written exam
b) three further units formally examined (by written exam, take-home exam or mini-project)
c) three other units

There is an optional dissertation which replaces one (or two) of the units in b) and c).

Classification (distinction/merit/pass/fail) is based on the average in your 7 assessed units and course completion. If you do more than 7 assessed units we will select your 7 best.

http://mmathphys.physics.ox.ac.uk/students

QFT (MT24) Groups&Reps (MT24) Advanced QFT (HT24)

GR I (MT16)

Alg. Geometry (MT16)

Perturbation Meth. (MT16)

Alg. Topology (MT16)

Num. linear algebra (MT16)

Diff. Geometry (MT16)

GR II (HT16)

SUSY & SUGRA (HT16)

String Theory I (HT16)

Appl. Compl. Var. (HT16) Astroparticles (HT8)

Cosmology (HT16)

Symb. Scientific Prog. (HT16) Geom. Group Theory (HT16)

Renormalization group (HT20)

String Theory II (TT16)

SM & Beyond I (TT16)

QFT in curved space (TT16)

SM & Beyond II (TT16) CFT (TT16)

Astroparticle, cosmology

String Theory

Particle phenomenology

Gauge theories, QFT

Mathematical foundations

Mathematical foundations is not a single pathway:

- Mathematics underpins all parts of physics.
- Much of mathematics, pure and applied, is used in this process.

If you are coming from physics, if you are interested in

- particle physics and string theory you will benefit from: groups and representations, differential geometry, algebraic geometry,
- fluids, condensed matter or plasmas, you will benefit from perturbation methods, complex variables, numerical linear algebra, scientific computing.

If you are coming from Mathematics with an interest in

- geometry and topology, this underpins general relativity, string theory compactifications, AdS/CFT and supersymmetric systems.
- group theory and algebra underpin all quantum systems from condensed matter to particle physics and quantum information.
- analysis, both pure and applied, underpins all differential equations from fluids through to GR and quantum theory.

Most parts of theoretical physics can be studied from a mathematical perspective.

MMath part C courses not on MTP list

See: link to part C at https://courses.maths.ox.ac.uk/overview/

Michaelmas	Hilary
Model Theory	Godel's Incompleteness Theorem
Analytic Topology	Axiomatic Set Theory
Lie Algebras	Representation Theory of Lie Algebras
Homological Algebra	Infinite Groups
Category Theory	Non-Commutative Rings
Elliptic Curves	Introduction to Schemes
Functional Analysis	Lie Groups
Functional Analytic Methods for PDEs	Probabilistic Combinatorics
Complex Analysis: Conformal Maps & Geometry	Analytic Number Theory
Solid Mechanics	Computational Algebraic Topology
Topics in Fluid Mechanics	Linear Operators
Mathematical Geoscience	Fixed Point Methods for Nonlinear PDEs
Mathematical Physiology	Elasticity and Plasticity
Approximation of Functions	Mathematical Mechanical Biology
Stochastic Differential Equations	Continuous Optimisation
Combinatorics	Finite Element Method for PDEs
	Stochastic Analysis and PDEs

Up to 3 units can be taken from the part C's of both MMath and MPhys.
Authorization from director of studies is required by week 4 MT.

If you dont see a dissertation topic in the handbook that is right for you, ask around!

Condensed Matter: On offer :

Advanced Quantum Theory =

Quantum Field Theory, Feynman Path Integrals (including finite temperature!), Quantum Many Body Physics (leads into Quantum Matter, HT)

Nonequilibrium Statistical Mechanics =

Systems out of equilibrium, Stochastic systems, Fluctuations, growth, diffusion, Non-hbar for this course. (leads to **Soft-Matter**, HT)

Topological Phases of Matter *(2016 Nobel Prize)* =

Topological quantum field theory, topological quantum matter, topological quantum information and quantum computing. Field arose from ideas in quantum gravity, topology, and condensed matter physics. (leads to Quantum Computing HT, Quantum Matter HT),

Renormalizaton Group

Fundamental to our understanding of all field theories.

Soft and active matter physics, Quantum CMP, etc.

FLUID DYNAMICS **ASTROPHYSICS** **PLASMA PHYSICS**

Kinetic Theory

gas kinetics gravitational kinetics plasma kinetics

⟶ **Non-equilibrium Statistical Physics**

Advanced Fluid Dynamics

non-Newtonian fluids magnetohydrodynamics

⟶ **Soft matter** (liquid crystals, polymers, biological materials...)

Geophysical Fluid Dynamics

Galactic & Planetary Dynamics

Astroparticle Physics

Cosmology

GR, particle theory…

Collisionless Plasma Physics

Collisional Plasma Physics

What are the possible pathways?

Pathway	*MT*	*HT*	*TT*
Generalist Theoretical Physicist *"TEORICA UNIVERSALIS"* **Core 5.25 units** Total 10.25-11.75 units	**1. QFT 24** **2-4. *Three of*** **Kinetic Theory 28** **GR I 16** **Pert. Methods 16**	1-3. *Three of* **Noneq. Stat. Phys 16** Advanced QFT 24 Renormalisation Group 16* Advanced Quan. Th. 20 Adv. Fluid Dyn. 16 Soft Matter 16 Collisionless Plasma Physics 18 Cosmology 16	1-3. *Three of* Quantum Matter 16 Standard Model 16* QFT in Curved Space 16 Dissertation
Hard-core String Theorist *"SUPERCORDULA"* **Core 7.5 units** Total 10.5 units	**1. QFT 24** **2. Groups & Repr. 24** 3. *One of* GR I 16 Pert. Methods 16 Diff. Geometry 16 Algebraic Geometry 16	**1. Advanced QFT 24** **2. String Theory I 16** 3. *One of* SUSY & SUGRA 16 GR II 16 Cosmology 16	**1. String Theory II 16** **2. CFT 16** 3. *One of* The Standard Model 16* (Aspects of) Beyond the SM & Astroparticle Phys. 16* QFT in Curved Space 16
Condensed Matter Theorist *"CONDENSATA"* **Core 4.5 units** Total 11–12.75 units	**1. QFT 24** 2. Advanced Quant. Th. 20 3.*One of* Kinetic Theory 28 Topological Quantum Theory 16	**1. Noneq. Stat. Phys. 16** **2. Soft Matter 16** 3. Advanced QFT 24 4. Adv. Fluid Dyn. 16 5. Renormalisation Group 16*	**1. Quantum Matter 16** 2. Topics Quant. CMP 8 3. Topics Soft Matter 8 4. CFT 16

and many more….

- General Theoretical Physics,
- Applied Mathematician,
- Fluid Dynamicist,
- Mathematician with a Physics Streak
- Particle Phenomenologist,
- Hard Core String Theorist,
- Condensed Matter Theorist,
- Hard Condensed Matter Theorist,
- Soft Condensed Matter Theorist,
- All Around Astrophysicist,
- Dedicated Cosmologist,
- Plasma Theorist

Even Better: Roll your own!

This is a serious, high-level master course with material all the way up to the threshold of research.

How do I apply?

Just fill in the online form

https://mmathphys.physics.ox.ac.uk/apply

Takes you to
https://www.maths.ox.ac.uk/members/students/undergraduate-courses/mmathphys-msc-mtp/mmathphys

Deadline: Friday 19 January 2024

But you can miss the deadline and we will still take you ....
... So don’t worry too much about it

What are the admissions criteria?

We are looking for students with a first class or strong upper second class BA performance (68+ average)

There is no quota. We will accept anyone with 68+

What if I get accepted but change my mind?

You can return to your original MPhys/MMath/MPhysPhil degree until week 4 of MT.

Which degree will I receive?

"Master in Mathematical and Theoretical Physics"
(MMathPhys)

with a double-classification consisting of your

- BA degree class in your original subject classified as 1, 2.1, etc.
- MMathPhys degrees classified as "distinction", "merit" "pass", "fail".