Mathematical and Theoretical Physics Induction

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Announcements:

- Surgery (course choices etc.): 11-12 Thursday 10th October, Classroom C1 Maths Inst. (optional).
- New regulation:
  When homework is part of the assessment, submission of homework counts as registering for assessment for that course and *you cannot then withdraw*.
  Failing to submit any further work will lead to an F on the transcript.
- We need 2 course reps for the JSC, one from MMathPhys, one from MSc.
  Please volunteer if interested!

Mathematical foundations

Mathematical foundations is not of itself a coherent 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.

Mathematical Foundations pathways

Pathway	*MT*	*HT*	*TT*
Fluid Dynamicist *"CONTINUA"* **Core 4.5 units** Total 10 - 10.75 units	**1. Kinetic Theory 28** **2. Pert. Methods 16**	**1. Adv. Fluid Dyn. 16** 2. *Three of* Soft Matter Phys. 16 Collisionless Plasmas 18 Geophysical Fluids 16 Complex Variables 16	1-2 *Two of* Collisional Plasmas 18 Astrophysical Gas Dyn. 20 Dissertation
Applied Mathematician *"APPLICATA"* **Core 5.5–7.25 units** Total 10–11 units	**1-2. Two of** **Noneq. Stat. Phys. 24** **Kinetic Theory 28** **GR I 16** **3. Pert. Methods 16** 4. *One of* **Diff. Geometry 16** Num. Lin. Algebra 16	**1. Adv. Fluid Dyn. 16** 2. *One of* Geophysical Fluids 16 Networks 16 Collisionless Plasmas 18 Galactic Dyn. 16 GR II 16 **3. Complex Variables 16**	1-2. *Two of* Collisional Plasmas 18 Astrophysical Gas Dyn. 20 (10HT, 10 TT) Dissertation
Mathematical physicist *"GEOMETRA"* **Core 5.5 units** Total 10–10.5 units	**1. QFT 24** **2. GR I 16** **3. Diff. Geometry 16** 4. *One of* Groups & Repr. 24 Algebraic Topology 16 Algebraic Geometry 16 Topological Field Th. 16	**1. String Theory I 16** 2. *One of* Advanced QFT 24 SUSY & SUGRA 16 GR II 16 Geom. Group Theory 16 Quantum Information 16	**1. String Theory II 16** 2. *Two of* CFT 16 Gauge-String Duality 16 The Standard Model 16* Beyond the SM 16 QFT in Curved Space 16*

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)*		
	Conformal Field Theory $^{(*)}$ (16)		

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!

Where does it lead in Oxford Maths?

In the Mathematical Physics group:

- Strings and Calabi-Yau compactifications.
- Exact computations in quantum supersymmetric gauge theories, AdS/CFT and string compactifications.
- Exact results in conformal field theory.
- Scattering amplitudes via twistors, galois theory of periods or AdS/CFT.
- Amplitudes/Calabi-Yaus and number theory.
- Quantum information/foundations.

In other groups:

- Homological mirror symmetry in geometry.
- Topological quantum field theories in topology (and computer science).
- Fluids, plasmas, geophysics and Mathematical Biology in OCIAM.
- The differential equations of mathematical physics in OXPDE.

and no doubt many more.