# MSc in Theoretical Physics
## Reading list

These notes cover a large range of background material for the MSc in Theoretical Physics and also suggestions for further reading. They and all the files listed here are available from page

www.kcl.ac.uk/schools/pse/maths/research/thphys/msc-background.html

The introductory course cmms30 given in the first weeks of the first semester reviews the necessary background material but if students have not seen it before they take the course they will find it hard work to learn it in the two to three weeks available.

Many students will have studied most of this material, some will have studied it all, and some will not have studied one or possibly two areas at all. Since we ask all students to complete a survey of their background knowledge as part of the admissions procedure, if a student has not studied a particular area then they should have discussed this already with the program advisor and it should be clear to them which parts they need to work on.

Lastly, whether or not they have covered all this material in their first degree, all students should benefit from revision of their undergraduate studies before they arrive.

Here are some notes on the areas of

1. Classical Mechanics
2. Special Relativity
3. Quantum Mechanics
4. Group Theory

## 1. Classical Mechanics

We expect students to be familiar with elementary Lagrangian and Hamiltonian treatments of classical mechanics, for example to know the Lagrangian and Hamiltonian formulations for the motion of a classical particle in a potential in one dimension.

This background material is covered in our undergraduate courses CM131A Introduction to Dynamical Systems and CM231A Intermediate Dynamics

Lecture notes and their study guide for CM131A are available from

www.kcl.ac.uk/schools/pse/maths/research/thphys/msc-background.html

In particular, students should be familiar with sections 6 and 7 of the notes for CM131A.

This material will be reviewed in cmms30.

The recommended text book for this material is:

H. Goldstein, Classical Mechanics, Addison-Wesley

This book contains a very great deal that goes beyond the requirements of the MSc course, but it is a great advantage to have studied symmetry in Lagrangian and Hamiltonian frameworks which is covered in sections 2–6 and 9–7 of the 2nd edition.

A range of further material is usually available from

www.mth.kcl.ac.uk/courses/cm131.html

www.mth.kcl.ac.uk/courses/cm231.html

## 2. Special Relativity

We expect students to be acquainted with the fundamentals of special relativity, with Lorentz transformations, with special relativistic mechanics and with its tensorial treatment. It is a great advantage to understand electromagnetism in tensorial (4-vector) notation.

This material will be reviewed in cmms30.

The relevant background material is covered in our undergraduate course CM331A Special Relativity and Electromagnetism

The lecture notes for this course are available here:

www.kcl.ac.uk/schools/pse/maths/research/thphys/msc-background.html

The recommended books for the course, which naturally cover far more than is required, are

J D Jackson, Classical Electrodynamics
W Rindler, Essential Relativity
A Einstein, Relativity
R Feynman, Lectures on Physics, vols I and II

A range of further material is usually available from

www.mth.kcl.ac.uk/courses/cm331.html

### 3. Quantum Mechanics

The relevant background material is covered in our undergraduate course CM332C Introductory Quantum Theory.

The lecture notes for this course are available at

www.kcl.ac.uk/schools/pse/maths/research/thphys/msc-background.html

A large amount of further information is usually available at

www.mth.kcl.ac.uk/courses/cm332.html

Some recommended texts:

B H Bransden and C J Joachain, Quantum Mechanics
L I Schiff, Quantum Mechanics
E Merzbacher, Quantum Mechanics
K Hannabuss, An Introduction to Quantum Theory
A Messiah, Quantum Mechanics I, II
R Feynman, Lectures on Physics vol III
R Shankar, Principle of Quantum Mechanics (2nd edition)

All these books contain the essential background material on the formulation of quantum mechanics and treatment of some simple models, and all also include material that will be taught in the the MSc course cmms31.

For example, from the last book, the essentials of chapters 2, 4 and 7 will be reviewed in CMMS30 Mechanics, Relativity, Quantum Theory, but rather quickly. Chapters 8, 11, 13, 14, 15, 17, 19 and 20 will be taught in CMMS31 Quantum Mechanics II

As a guide, in this last book, the following is important background material:

1 Mathematical Introduction
2 Review of Classical Mechanics (2.2 and 2.6 can be omitted on a first reading)
3 All is not well with classical mechanics

The standard framework —

4 The postulates (The density matrix 4.2.20-4.2.23 can be omitted)

Two chapters on example systems -

5 Simple Problems in one dimension
7 The Harmonic Oscillator

For later reading:

9 The Heisenberg Uncertainty Principle -
6 The Classical limit: would be interesting to read

For those who have not studied quantum mechanics before, one can approach quantum mechanics in at least two ways - either from the physics (read chapter 3 first) or from the mathematics (read chapter 1 first). The essentials of quantum mechanics are the postulates - in chapter 4 - and then the work is deciding how to set up a physical system in that framework and solving it. Chapters 5 and 7 do that for two simple set-ups

**4. Group Theory**

The relevant background material is covered in our undergraduate course

CM232A Groups and Symmetries

We expect students to be acquainted with the definition of a group, to have met some examples of finite groups, and ideally to know the definitions of the groups so(3), su(2), so(n) and su(n).

This material will be reviewed in cmms30. It will be greatly developed in cmms01

There are innumerable books available - one can go to any mathematics or university library and pick any book with "group theory" in the title and read the first few chapters.

Most elementary books on group theory discuss finite groups first - those with a finite number of elements. This is a good way to see how the definitions work and some of the elementary properties. Finite groups play an important role in physics, for example the symmetry of parity (space-inversion) generates a group with two elements and the symmetric group S(n) is important in the discussion of Bose and Fermi statistics.

Mathematics book often then embark on extended discussions of the structural properties, classification theorems, etc of finite groups which are not needed in the MSc course.

Instead it would be more useful to read about matrix groups such as the rotation group, the Lorentz group and other continuous groups.

Also useful is the idea of a "representation" of a group, a topic which is often not covered in elementary mathematics books but which plays a central role in understanding symmetries in quantum mechanics. This central topic can be developed in a variety of languages which are more appealing to the physicist or the mathematician.

A book with a physics audience in mind is for example

> "Groups, representations and physics"
> H.F. Jones (Institute of Physics Publishing, 1998)

and a reference for matrix groups is

> "Matrix groups : An introduction to Lie group theory"
> Andrew Baker (Springer, 2002)

where again the text is more advanced than needed for the MSc program, but it would be good to know what is written in the first one or two chapters.

There are also online lecture notes, for example

`www.jmilne.org/math/CourseNotes/math594g.html`

For cmms01 it would be good to have at least seen the basic definitions in chapter 1 and parts of chapter 4.