MATH60015/70015
Quantum Mechanics I
Module guide academic year 2024/25

Course instructors

Lecturer

- Dr Eva-Maria Graefe, e.m.graefe@ic.ac.uk, Huxley, 6M35

Module overview

Quantum mechanics is one of the most successful theories in modern physics and has an exceptionally beautiful underlying mathematical structure. It provides the basis for many areas of contemporary physics, including atomic and molecular, condensed matter, high-energy particle physics, quantum information theory, and quantum cosmology, and has led to countless technological applications.

This course aims to provide an introduction to quantum phenomena and their mathematical description. Quantum theory combines tools and concepts from various areas of mathematics and physics, such as classical mechanics, linear algebra, probability theory, numerical methods, analysis and even geometry. However, most of the concepts are basic, and little background knowledge is required before we can put them to practical use.

This course is designed mostly for those without prior knowledge of quantum mechanics, but maybe suitable even if you have taken another introductory course in quantum mechanics before. Please consult your program director in this case.

There are no formal prerequisites for the course. It would be well matched with the course MATH60011/70011 Classical Dynamics. The content of the present course is considered a prerequisite for the course MATH60018/70018 Quantum Mechanics II.

Term dates and course structure

This module runs in term 1. There are ten module weeks (aligning roughly with weeks 2 to 11 of the term). The content is divided into nine Chapters, allowing for a revision week in the middle of the term, ahead of a class test. We begin with an introductory lecture on Friday the 4th of October, followed by a two hour lecture on Chapter 1 on Tuesday the 8th of October. From then onwards module weeks **start on Wednesday mornings** and **end with the following Tuesday's interactive lectures (9:00 - 10:50)**. The module runs from the **4th of October** until the **12th of December**. See the course calendar at the end of this document for a detailed overview of course activities.

Structure of each module week

- A set of **typed notes** covering the week's material will be released every **Wednesday morning**. You should work through this during the week. In addition, in most weeks a small number of **videos** will be made available that cover selected parts of the content of the lecture notes for you to use as complementary study material.

- A **problem sheet** with some problems for you to solve independently for additional practice at home is released each **Wednesday**. Typed solutions to these will be released the following week.

- On **Fridays from 12:00 to 12:50** there is a timetabled lecture in **Huxley 340**. The first two weeks this slot will be used for lectures. From then on (with the exception of Friday the 8th of November, on which day there will be a revision session for the in-class test the following week), these slots will be dedicated to **guided exam practice**. In each of the sessions an old exam questions building only on material covered up to the relevant week will be provided for you to practice. I will be there to provide guidance and advice, and to present (parts of) the solution on the board.

- In most weeks there will be a **set of short exercises** for you to solve before completing a **multiple choice test** the following Monday, ahead of the Tuesday lecture. **The tests on Chapters 3, 4, 5,**

7, 8, and 9 each count for 1% **of the overall course mark**. Completing the calculations and the test should take you no longer than an hour. The purpose of this is to give you an incentive to work through the material before the live lecture at the end of the lecture week.

- On **Tuesdays from 9:00 to 10:50** there are **interactive lectures** scheduled to take place in the **340 Huxley building**. It will be assumed that you have worked through the material for the week in advance of the session, but if on an odd occasion you have not managed to do so, please make an effort to attend the session anyhow, reading through as much of the material in advance as possible. In these sessions we will go through examples for the week's content and discuss some aspects in more detail. This will also give you a chance to ask questions about the lecture material, and to interact with your fellow students on the course. Your active participation will be expected in these sessions!
- **Office hours** are on **Tuesdays from 12:00 to 13:00**. During these I will be available for one-to-one meetings or small group discussions in my office (Huxley 6M35). If you need to talk to me but are not free during this time, please email me to arrange a meeting at another time.

Online material on blackboard

On the blackboard page for the course you will find folders named **Chapter 1** to **Chapter 9**, containing the learning material for each of the module weeks. In each of these folders, from the beginning of the respective module week you will be able to access

- A **Roadmap** for the week, containing a list of the learning material for the week and a suggested workflow through the material. You should use this document to make sure you did not miss any of the content;
- A list of **learning objectives for the week**;
- The **problem sheet** for the Chapter, and **model solutions** that will be uploaded with some delay;
- The relevant chapter of typed **lecture notes**, covering the week's content;
- Links to a small number of additional **lecture videos** for the relevant week;
- In weeks 2, 3, 4, 5, 7, 8 and 9, there will be an **exercise sheet** and **multiple choice assessment** for the week to be completed by Monday at 4pm.

Further, there will be an **Ed discussion board** linked from blackboard that you should make use of for questions on the lecture material and problem sheets and further discussions. It is also a good place to indicate which topics you would like to be addressed in the interactive sessions. I will watch and moderate the forum. It is encouraged that you try to answer each others questions here. During weekdays I will aim to respond to any questions or correct or expand on existing student answers within 48 hours.

Suggested work process

At the beginning of each week, i.e. on **Wednesday morning**, you should log on to blackboard, navigate to the folder for the correct week and

- Download the roadmap for the week;
- Download and read the learning objectives for the week;
- Download the problem sheet for the week;
- Download the lecture notes for the week;

Of course you can work through the material in whichever order you feel most comfortable with. For example, it is entirely up to you whether you prefer to read only the notes or use both notes and videos and if using both, you can read the notes first and then watch the videos, watch the videos first or go back and forth between them. It is probably best to divide this working through the material into several blocks, starting **no later than Thursday morning** and finish working through the material **no later than the following Monday morning**. It can be useful to look at the problem sheet and multiple choice exercise sheet early on and observe what you can make sense of already, and what makes no sense at all. Then, once you have

worked through the material return to the problem sheet and hopefully you will know what to do then. Even though the problem sheets are not assessed, try to work through them each week, as they provide practice and often complement the lecture material. There is little use in saving them for the end of term.

Make sure you complete the exercises for the multiple choice test by **Monday** and complete the **multiple choice assessment on blackboard** by **Monday at 4pm**.

From the third week onwards, the Friday lecture slot will be devoted to exam practice, using (parts of) old exam questions building only on material covered up to the relevant week.

If you have any topics you'd like to discuss privately, come to see me in my office Huxley 6M35 during the office hours between 12:00 and 13:00 on Tuesdays (or arrange a call on teams during these times).

On **Tuesday** attend the live session and be prepared to participate, ask questions and join discussions.

On **Wednesday morning** start again with the following week's content.

Live lectures

Live lectures will take place **every Tuesday, starting on the 8th of October**. The last session will take place on Tuesday the 10th of December. These will take place in person in Huxley 340 from 9:00 to 10:50.

These sessions form an integral part of the lecture, so try not to miss them if at all possible. They are highly interactive. Be prepared to participate in group discussions, solve short problems, and most importantly ask questions.

The sessions will be recorded, but since they are highly interactive watching the recordings will be less useful than attending.

Office hours

During the term I will be available for one-to-one meetings every Tuesday (starting from the 8th of October) between 12:00 and 13:00. You can try to arrange a slot in advance or simply come to my office, if you have anything you'd like to discuss in person. Of course if several of you want to group up for this purpose this is fine too. If you need to discuss anything but cannot make the time slots, email me (e.m.graefe@ic.ac.uk) to arrange a meeting at another time.

Ed discussion forum

There is an Ed discussion forum dedicated to the course. There will be several threads related to different aspects of the course (e.g. problem sheets, suspected typos in the notes, etc), and this may be amended as the course goes on. Please make use of this discussion forum to post your questions, answer each others questions, and participate in further discussions about quantum mechanics. You can also post anonymously, should you wish to do so. The discussion forum will be monitored and moderated by the course instructors. We will aim to answer any questions posted or correct or extend student answers within 48 hours during working days.

This discussion forum is a safe space and no abusive, patronising, or condescending comments will be tolerated. In other words: Be nice to each other, behave yourselves, and use the opportunity for constructive and stimulating discussions!

Assessment

The course is assessed by an **exam** in May or June 2025 **counting for** 90% **of the overall mark**, **six multiple choice tests, each counting for** 1% **of the overall mark**, and an **in-class test counting for** 4% **of the overall mark**. The multiple choice assessments are based on the solutions of a set of short exercises that will be released on blackboard at the beginning of the relevant module week (3,4,5,7, 8 and 9). The deadline for completion of the multiple choice tests is Monday at 4pm of each module week. The in-class test will take place during the usual Tuesday lecture slot on the 12th of November.

Feedback

You will receive written feedback on the class test. Informal and peer-to-peer feedback will be provided via the discussion forum and in the interactive lecture sessions.

Module content - table of contents of the lecture notes[1]

Reading list

The course lecture notes are largely self-contained. They borrow from various textbooks, a number of which are highly recommended for additional reading. A leganto reading list is available on blackboard.

[1] Indicative table of contents - may be subject to slight amendments

Course calendar

October

1	Tu			
2	We			
3	Th			
4	Fr	intro lecture		
5	**Sa**			
6	**Su**			
7	Mo			41
8	Tu	lecture 1 Chapter 1	Chapter 1	
9	We			
10	Th			
11	Fr	lecture2 Chapter 1		
12	**Sa**			
13	**Su**			
14	Mo	MC test Chapter 2 (0%)	Chapter 2	42
15	Tu	lecture Chapter 2		
16	We			
17	Th			
18	Fr	exam practice 1	Chapter 3	
19	**Sa**			
20	**Su**			
21	Mo	MC test Chapter 3 (1%)		43
22	Tu	lecture Chapter 3		
23	We			
24	Th			
25	Fr	exam practice2	Chapter 4	
26	**Sa**			
27	**Su**			
28	Mo	MC test Chapter 4 (1%)		44
29	Tu	lecture Chapter 4		
30	We			
31	Th			

November

1	Fr	exam practice 3	Chapter 5	
2	**Sa**			
3	**Su**			
4	Mo	MC test Chapter 5 (1%)		45
5	Tu	lecture Chapter 5		
6	We			
7	Th			
8	Fr	revision class	Revision	
9	**Sa**			
10	**Su**			
11	Mo			46
12	Tu	Class test (4%)		
13	We			
14	Th		Chapter 6	
15	Fr	exam practice 4		
16	**Sa**			
17	**Su**			
18	Mo			47
19	Tu	lecture Chapter 6		
20	We			
21	Th			
22	Fr	exam practice 5	Chapter 7	
23	**Sa**			
24	**Su**			
25	Mo	MC test Chapter 7 (1%)		48
26	Tu	lecture Chapter 7		
27	We			
28	Th		Chapter 8	
29	Fr	exam practice 6		
30	**Sa**			

December

1	**Su**			
2	Mo	MC test Chapter 8 (1%)		49
3	Tu	lecture Chapter 8		
4	We			
5	Th		Chapter 9	
6	Fr	exam practice 7		
7	**Sa**			
8	**Su**			
9	Mo	MC test Chapter 9 (1%)		50
10	Tu	lecture Chapter 9		
11	We			
12	Th	exam practice 8		
13	Fr			
14	**Sa**			
15	**Su**	end of term		
16	Mo			51
17	Tu			
18	We			
19	Th			
20	Fr			
21	**Sa**			
22	**Su**			
23	Mo			52
24	Tu			
25	**We**	**Christmas Day**		
26	**Th**	**Boxing Day**		
27	Fr			
28	**Sa**			
29	**Su**			
30	Mo			1
31	Tu			