Introduction to Quantum and Molecular Computing

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1 Introduction to the Course

This course aims to provide you with a basic understanding of some of the fundamental ideas in both quantum and molecular computing. Assessment of this course is through a single 1.5-hour exam covering both parts, which you will take in May/June. The banner code for this module is 06-12411.

There will two one hour lectures per week, at:

- 12pm on Mondays in room LT3, Sports and Exercise Science
- 12pm on Tuesdays in room UG05, Learning Centre

There will also be one exercise class, at:

- 1pm on Tuesdays in room G18, Nuffield Building

Outside of the lectures, feel free to send me an email at any time, or come to my office hour:

- Mondays from 2pm to 3:30pm in room 109

If you wish to see me at another time please send an email suggesting a few possibilities, and I'll do my best to accomodate you.

Further information about the course can be found at the module description web page:

`http://www.cs.bham.ac.uk/resources/modules/2008/mds/md-12411.html`

the syllabus page:

`http://www.cs.bham.ac.uk/resources/modules/2005/12411.html`

and the course home page:

`http://www.cs.bham.ac.uk/internal/courses/intro-mqc/current/`

This is where copies of the exercise sheets and handouts will be found. In addition, a few paper copies of the handouts will be placed in the module box in the library.

2 Recommended Books

There are several books whch you may find useful. On Quantum Computation, the following books are useful

2.1 Quantum Computation

The main recommended book for this section is:

- Quantum Computer Science. N David Mermin (Cambridge University Press, 2007). *This is by far the best book for the beginner, especially for those with no background in Physics/Quantum Mechanics. David Mermin is well known for the clarity of his writing, and this book is an exceptional example.*

I have also found the following texts useful

- Quantum Computation and Quantum Information. Michael A. Nielsen and Isaac L. Chuang (Cambridge University Press, 2002).
  A clear introduction at the right level. The chapter on Quantum Mechanics is especially useful. There are several copies of this text in the school library, and one copy in the main library, under classmark QA 76.889/N.
- Feynman Lectures on Computation. Richard P. Feynman (Addison Wesley, 1996). *An instant classic text. Very readable and always enlightening. Contains the classic article which kicked off the whole area of quantum computation. Copies in the school library, and in the main library under classmark QA 76/F.*
- Quantum Computing. Where do we want to go tomorrow? S. Braunstein (Wiley-VCH, 1999). *A nice collection of articles which are really beyond the scope of the course, but are nonetheless interesting in their own right. Copies in the main library under classmark QA 76.889/Q.*
- Explorations in Quantum Computing. Colin P. Williams and Scott H. Clearwater (Springer-Verlag, 1997). *A nice text at the right level. Quite good at spelling out the details. Copies in the school library and the main library under classmark QA 76.889/W.*
- Modern Quantum Mechanics. J. J. Sakurai (Addison-Wesley, 1994). *A classic text on quantum mechanics. Contains much more detail than you need. Copies in the main library under classmark QC 174.1.*

The following resources on the web could also be helpful:

- http://www.qubit.org/ *Oxford University Centre for Quantum Computation, has links to lots of people and articles.*

- http://www.theory.caltech.edu/people/preskill/ph229/ *John Preskill's excellent notes for his lectures at Caltech. Far beyond the level of this course.*

Links to these pages can be found on the course web page.

3 A word on Mathematics

This course (especially the first part on quantum computing) does require a significant amount of mathematics. I make no apology for this: mathematics is the natural language in which to express the ideas behind quantum mechancis, and if we wish to understand quantum computing in any detail at all, there is no avoiding it. However, I have taken care to use only the mathematics that is really needed. The key areas you'll need to be familiar with are:

- Complex Numbers: sound harder than they really are. I have produced a primer which is available on the course web site, together with some examples (I will make solutions available in good time). If you are already comfortable with complex numbers, you won't need the handout, but if you haven't encountered them before, or are a little rusty, I urge you to read the primer and try the examples (and more, if you feel the need). A good textbook for learning about complex numbers is *Engineering Mathematics, K.A.Stroud (MacMillan Press, 1995), available in the main library under classmark TA345.*
- Linear Algebra: I will assume that you know what matrices and vectors are, and can do simple manipulations: addition, multiplication etc. We will cover some more advanced material (unitarity, tensor product) as it is needed in the course. If you are rusty, then I recommend *Advanced Engineering Mathematics, Peter V. O'Neil (PWS Publishing Company, 1995), available in the main library under classmark TA345.*
- Probability: I will assume that you know what a probability distribution is, that it must be normalised, and that you understand what it means to say that something is probabilistic.

The best way to improve your mathematics is to practice it, and you should try to do as many problems as you can. In the weekly exercise sheets, there will be some questions to give you practice in the (quite simple) mathematical manipulations that are required.