Faculty of Engineering
School of Electrical Engineering and Telecommunications

ELEC 9705
Quantum Devices

Session 2, 2009
Course Introduction
1. COURSE STAFF

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Guest lectures by research specialists may be delivered during the session.

2. COURSE INFORMATION

Units of credit: This is a 6 UoC course; expected workload is 10-12 hours per week throughout the session.

Contact hours: The course consists of one 3-hour lecture per week:

- Tuesday       18:00 – 21:00    Quadrangle G032.

According to the 12-weeks-in-13 model, the lectures will start in week 1 and run until week 12. The contact hours in week 13 might be utilized for a final Q&A session and/or an exam simulation.

During the first 12 weeks, occasional changes in the schedule may be necessary at times, and will be discussed with the students to ensure that everyone is able to attend all lectures.

There will be no laboratories or tutorials.

Programs: The course is available in the following programs:

- Master of Engineering Science;
- PhD in Electrical Engineering;
- Bachelor of Engineering (4th Year Elective substitution).
3. AIMS AND SCOPE

The progress of nanotechnology has started to allow the fabrication of devices whose dynamics no longer obeys the laws of classical physics. Such devices behave according to Quantum Mechanics, which opens the possibility to exploit entanglement and quantum superpositions to perform otherwise cumbersome or impossible tasks. These include the efficient solution of hard computational problems, or the secure teleportation of information.

This course on Quantum Devices aims to provide a deep but accessible introduction to the properties of nano-engineered devices that are designed to be the building blocks of future quantum information and communication systems. Such devices allow to observe and manipulate individual electron charges, measure their spin state, and couple them to quantized electromagnetic fields. Some of these devices also represent the ultimate detectors of electric and magnetic signals, with sensitivity limited by the fundamental quantum mechanical uncertainty. The relevance of Quantum Mechanics in advanced electronic devices will be illustrated by discussing in details several practical examples:

- **Single-electron transistor** - the most sensitive electrometer, capable of detecting the displacement of a single electron charge in its vicinity;
- **Quantum point contact** - an electrical conductor with cross-section comparable to the electronic wavelength;
- **Superconducting Quantum Interference Device** - the most sensitive magnetometer, able to detect a fraction of a magnetic flux quantum;
- **Charge, phase, and flux qubits** - micron-size electrical circuits that can be prepared in a macroscopic quantum superposition of different states;
- **Quantum dots** - also known as `artificial atoms`: nanostructures that confine a small number of electrons and allow the preparation and observation of their charge and spin states.

4. RELATION TO OTHER COURSES

ELEC9705 Quantum Devices is a stand-alone course, with no prerequisites and no following courses. It is assumed that the students are familiar with linear algebra, basic circuit theory and electromagnetism, but no previous knowledge of Quantum Mechanics is assumed or expected.

The course naturally complements GSOE9220 Quantum Information and Computation, and TELE7959 Quantum Communications. The three courses taken together provide a complete pedagogical package on emerging quantum technologies, covering “quantum hardware” (ELEC9705), “quantum software” (GSOE9220), and “quantum communications” (TELE7959).

5. LEARNING OUTCOMES

At the end of the course, the students are expected to be familiar with the basic concepts of Quantum Mechanics, and be able to recognize its relevance for the technological progress in electronic devices. They will be able to appreciate the radically new range of device functionality that is made available to the engineer by the control of quantum systems. Also, the course will ideally prepare the students to participate in advanced post-graduate research projects, or work in specialized industries with high involvement in research and development.
6. **TEACHING METHOD**

The lecturers will deliver either white-board or projected PowerPoint lectures. Lecture notes and additional reading material will be progressively made available on the course WebCT website, but they are no substitute for accurate notes taken by the students during the lectures. This is because it is probable and desirable that many questions will arise during the lectures, and the outcomes of such discussions are hard to capture in lecture notes prepared in advance. It is therefore essential that students attend every lecture. The material covered by the course is rather unusual and it would be difficult for the students to assemble this knowledge by reading scattered references.

In addition, the use of Matlab code to solve simple quantum mechanical calculations will be discussed during the lectures, and will form the background for a mid-term assignment.

There will be no tutorials or laboratories.

7. **REFERENCES**

No textbook is formally set for this course. Recommended readings include:


Further specialized reading material will be made available on the course WebCT website.

8. **ASSESSMENT**

The assessment in this subject will be based for 80% on the final exam, and 20% on a mid-term assignment.

9. **PLAGIARISM**

Students found guilty of academic misconduct, in particular plagiarism - including excessive collaboration, copying another’s assignment, or allowing one’s assignment to be copied by another student - will not receive any marks for that assignment. In addition, any plagiarism will be referred to the Head of School for further action. Plagiarism is considered a serious offence by the University and severe penalties may apply. For more information about plagiarism, see [http://www.lc.unsw.edu.au/plagiarism/index.html](http://www.lc.unsw.edu.au/plagiarism/index.html).

10. **THE COURSE WEBSITE**

The WebCT Vista portal will be the primary point of contact, for administrative matters, with the student. Any important announcements will be placed on the ‘Announcements’ page, which the student is obliged to check regularly. Lecture notes, assignments and other course materials will also be made available for download from WebCT.

Those unfamiliar with WebCT should consult the following website, which contains instructions and other resources for students:

[http://support.vista.elearning.unsw.edu.au/content/default.cfm?ss=0](http://support.vista.elearning.unsw.edu.au/content/default.cfm?ss=0)