School of Informatics Teaching Course Proposal Form

This version was generated **November 25, 2015**. User 'cheunen@inf.ed.ac.uk' verified.

Proposal

Course Name: Categories and quantum informatics
Proposer's Name: Chris Heunen
Email Address: chris.heunen@ed.ac.uk
Course Year: 4
Names of any courses that this new course replaces :
n/a

Course Outline

Course Level: 11
Course Points: 10
Subject area: Informatics
Programme Collections:
Computer Science.

Teaching / Assessment

Number of Lectures: 20
Number of Tutorials or Lab Sessions: 8
Identified Pre-requisite Courses: Introduction to Linear Algebra, Introduction to Quantum Computing
Identified Co-requisite Courses: n/a
Identified Prohibited Combinations: n/a

Assessment Weightings:
Written Examination: 75%
Assessed Coursework: 25%
Oral Presentations: 0%

Description of Nature of Assessment:
Assessed coursework will be a selection from weekly exercise sheets

Course Details

Brief Course Description:

This course gives an introduction to some topics in monoidal category theory, and shows how we can use them to model phenomena in quantum informatics: * Abstract semantics, compositionality, categories * Monoidal categories, graphical calculus * Dual objects, entanglement, the quantum teleportation protocol * Monoids, no-cloning * Frobenius structures, measurement * Complementarity, ZX-calculus, the Deutsch-Jozsa algorithm * Complete positivity, quantum channels, the no-broadcasting theorem * The quantomatic proof assistant

Detailed list of Learning Objectives:

1: See the value of categorical semantics. 2: Understand and prove basic results about monoidal categories. 3: Fluently manipulate the graphical calculus for compact categories. 4: Model quantum protocols categorically and prove their correctness graphically. 5: Appreciate differences between categories modeling classical and quantum theory. 6: Work with Frobenius structures in monoidal categories. 7: Manipulate quantum algorithms in the ZX-calculus. 8: Explore graphical theories using the quantomatic software tool.

Syllabus Information:

The textbook "Categories for quantum theories", C. Heunen and J. Vicary, Oxford University Press, should appear before the course starts. (Additional) lecture notes and slides will be provided.

Recommended Reading List:

n/a

Any additional case for support information:

This course would fit on the theoretical end of the curriculum. It would give students easy (graphical) access to advanced semantic methods (category theory), filling a gap in the curriculum, and complementing the quantum computing course by providing students with a conceptual grasp. A similar course has been taught in Oxford for the last four years to 4th and 5th year students (see e.g. https://www.cs.ox.ac.uk/teaching/courses/2014-2015/cqm/). There will shortly actually be a textbook based on it with Oxford University Press (in the series Graduate Texts in Mathematics).

Although theoretical in nature, the course also includes a software practical. It is essential for the students to keep up with the lectures, whence weekly exercise classes are proposed.