Introduction to Differential Geometry
Instructor: Professor Nicholas McCleerey
Course Number: MA 49500DG
Credits: Three
Time: 2:30–3:20 PM MWF

Description

Differential geometry is devoted to the study of smooth spaces from an analytic perspective. The course will start by developing an understanding of how calculus on a "curved" space differs from calculus on the "flat" Euclidean space; this will lead us to the fundamental local invariants of differential geometry, including the curvature and torsion. We will then derive global ramifications of these local invariants, including, for example, the fact that one cannot produce a completely accurate map of Earth (preserving both distances and angles).

We will primarily focus on curves and surfaces inside R^3, aiming to develop intuition from working in a familiar setting; the latter part of the course may move beyond this, depending on time and interest.

Textbook: Manfredo P. Do Carmo, *Differential Geometry of Curves and Surfaces*

Prerequisites: Linear Algebra (MA 353 or comparable), Real Analysis (MA 341 or comparable)

Undergraduate Quantum Computing
Instructor: Professor Ralph Kaufmann
Course Number: MA 49500QC
Credits: Three
Time: 9:30–10:20 AM MWF

Description

This course will be an introduction to the theory underlying quantum computing and topological quantum computing for undergraduates. The course is designed to be self-contained. We will start with the basics of Boolean logic, linear algebra and the axioms and foundations of quantum mechanics. We will then go into spins, unitary matrices and quantum gates. As an application, we will discuss algorithms, such as Shor's algorithm and RSA encryption. We expect to cover topological quantum computing using anyons and if time permits further topics. This gives a solid background for work in this field.

The course is open to anyone in mathematics, physics, computer science, chemistry, science or engineering. A good working understanding of linear algebra will be useful. The pace of the course will be adjusted to the audience.

The basic outline is as follows:

1. Boolean logic
2. Linear algebra
    (a) Complex vector spaces
    (b) Hilbert spaces
    (c) Tensor products
3. Quantum mechanics
    (a) Axioms
    (b) Boch sphere
    (c) Spin systems

4. Quantum gates
   (a) Universal gate sets
   (b) Shor's algorithm
   (c) RSA
5. Topological quantum computing
   (a) Linear algebra II. Unitary representations
   (b) Spin coupling (Clebsch Gordan coefficients)
   (c) Anyon theory
6. Additional topics (depending on time and the audience)
   (a) Lattices and Toric code
   (b) Quantum error correction
   (c) Programming existing systems

The course will have its own script.

Some higher-level standard references are:

Quantum computation and Quantum Information by Nielsen Chuang.

Quantum Computer Science. Mermin.

Representations of Compact Lie Groups. Tom Dieck.