FINAL SYLLABUS

Monday 17 April – Quantum computing introduction: circuit-based paradigm

MORNING

9:00 – 9:25 Welcome speeches (25 minutes)

9:30 – 11:00 Intro to Quantum Computing 1 – Gianni Mossi (1.5 hour, active exercises within lecture)

- *Turing machines and computability*
- *Classes of complexity*
- *Probabilistic computation: Monte Carlo, Variational estimator, evolution and measurement*

11:10 – 12:10 Intro to Quantum Computing 2 – Kathrin Spendier (one hour, active exercises within lecture)

- *Computation by circuits: logic gates and circuits*
- *Bit versus qubit*
- *Bloch sphere, superposition, complex numbers, measurement, linear algebra*
- *The quantum circuit model*

12:10 – 13:30 LUNCH

AFTERNOON

13:30 – 14:30 Intro to Quantum Computing Exercise Session – Kathrin Spendier and **Callum Macpherson** (one hour, active exercises within lecture)

- *Short Hardware introduction/NISQ*
- *Introduction to TKET – overview, motivation, design*
- *Building quantum circuits – registers, gates, OpTypes*
- *Simulating quantum circuits, measurement, running on backends and sampling*
- *Transforming/compiling quantum circuits*
- *Finish up with a basic demo*

14:40 – 15:40 Grover's Algorithm – Callum Macpherson (one hour)

- *Grover's algorithm*

15:50 – 16:50 Adiabatic Quantum Computation – Glen Mbeng (one hour)
- *Introduction to adiabatic quantum computation*

Tuesday 18 April – Introduction to Error Mitigation and Error Correction in Quantum Information Theory

9:00 – 10:00 Adiabatic Quantum Computation – Glen Mbeng (one hour)
- *Adiabatic quantum computing and related algorithms*

10:10 – 11:10 Introduction to Quantum Error Mitigation 1 – Silas Dilkes, Cristina Cirstoiu, Dan Mills (one hour)
- *Quantum Error Mitigation Introduction*
- *Examples of Quantum Error Mitigation Schemes*
- *"Qermit" paper overview*

11:20 – 12:20 Introduction to Quantum Error Mitigation 2 – Silas Dilkes, Cristina Cirstoiu, Dan Mills (one hour)
- *Introduction to "Qermit" software package*

12:20 – 13:30 LUNCH

AFTERNOON

13:30 – 14:30 Quantum Error Correction 1 – Ben Criger, Ciaran Ryan-Anderson (one hour)
- *Intro to QEC (No cloning, errors are continuous, measurement)*
  - *Why we need it, levels of abstraction (gates etc..)*
- *From Rep code to Shor's code*
- *Simple exercises*

14:40 – 15:40 Quantum Error Correction 2 – Ben Criger, Ciaran Ryan-Anderson (one hour)
- *Group theory*
- *Paulis and Cliffords*
- *Simple exercises*

15:50 – 16:50 Quantum Error Correction 3 – Ben Criger, Ciaran Ryan-Anderson (one hour)
- *Overview of Stabilizer formalism*
- *[[n, k, d]] notation*

■ *Introduce surface code*
  ● *Simple exercises (surface code patches)*

17:00 – 18:00 Quantum Error Correction 4 – Ben Criger, Ciaran Ryan-Anderson (one hour)

  ● *Gottesman-Knill and Eastin-Knill Theorems*
  ● *Brief intro to magic*
  ● *Brief overview of more advanced topics we don't have time to cover*

Wednesday 19 April – Introduction to Quantum Computational Chemistry

MORNING

9:00 – 10:00 Introduction to Quantum Computational Chemistry 1 – Nathan Fitzpatrick (one hour)
- *Qubit encoding of the electronic structure*
- *Manipulating the wavefunction*
- *Hamiltonian construction*

10:10 – 11:10 Introduction to Quantum Computational Chemistry 2 – Nathan Fitzpatrick (one hour)
- *Variational quantum eigensolver and related NISQ algorithms*

11:20 – 12:20 Introduction to Quantum Computational Chemistry 3 – Nathan Fitzpatrick (one hour)
- *Quantum phase estimation*

12:20 – 14:00 LUNCH

AFTERNOON - EXERCICES

14:00 – 15:00 Introduction to Quantum Computational Chemistry 4 – Nathan Fitzpatrick (one hour)
- *Quantum signal processing/LCU approaches*

15:10 – 17:10 Quantum Computational Chemistry Exercise Session – Nathan Fitzpatrick (two hours)
- *Quantum chemistry exercises*

Thursday 20 April – Introduction to Diagrammatic Reasoning in Quantum Information Theory

MORNING

9:00 – 10:00 Bob Coecke (one hour)
- *Introduction to diagrammatic reasoning and ZX-calculus*

10:10 – 11:10 Bob Coecke (one hour)
- *Applications of ZX to QC*
- *ZX representation of Clifford + T circuits*
- *Quantum circuit optimisation (phase gadgets, T-count reduction…)*
- *Mention ZX(W) superficially and applications*

11:20 – 12:20 Bob Coecke (one hour)
- *Lecture on quantum compositionality*

12:20 – 14:00 LUNCH

AFTERNOON

14:00 – 15:00 Bob Coecke (one hour)
- *Lecture on compositionality and computational linguistics*

15:10 – 16:10 Konstantinos Meichanetzidis (one hour)
- *QNLP experiments*
- *Practice tutorial, exercises using LAMBEQ*

Friday 21 – Sunday 23 April: quantum hackathon

Friday 21 – Day 1:
08:00 - Arrival of the participants and breakfast
08:30 - Welcome speech from Quantinuum and introduction of the partners
09:00 - Beginning of the hackathon of Quantinuum day 1
12:00 - Lunch break
13:00 - Hackathon
17:00 - Dinner break
18:00 - Hackathon
19:00 - End of day

Saturday 22 – Day 2:
08:00 - Breakfast
08:30 - Beginning of the hackathon of Quantinuum day 2
12:00 - Lunch break
13:00 - Hackathon
17:00 - Dinner break
18:00 - Hackathon
19:00 - End of day

Sunday 23 – Day 3
08:30 – deadline to give the presentation material from each team
09:00 – beginning of the first part of the technical presentations (10' of presentation, 5' of Q&A, 5' of rollover)
10:30 – break
10:45 – second part of the technical presentations (10' of presentation, 5' of Q&A, 5' of rollover)
12:15 – end of the technical presentations
14:00 – TRANSFER to new venue: beginning of the cocktail party of the hackathon at Sala Teatro Piccola Fenice and award ceremony
20:00 – end of the cocktail party