Quantum Computing Final Project Task 4
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Question 1. Which modality do you think would be the first to support a functional quantum computer? Why do you think your chosen modality will be the first one in supporting a functional quantum computer? Compare at least three modalities.

In my opinion the first modality to support a fully functioning quantum computer will be the superconducting qubit. Most of the superconducting qubits have shown very high controllability and potential scalability. In comparison with linear optics qubits they have less losses. It's also much easier to make two qubits interact in superconducting qubits than it is for linear optics qubits. While in my opinion linear optics is the most aesthetic way to build a qubit, the amount of noise in such qubits is too high. In comparison to the ion trap qubits just don't have the coherence of the superconducting qubits. Moreover, gates for superconducting qubits are way faster than the ones for ion traps. Even though ion trap qubits are way more stable they get less attention as superconducting qubits are on the frontline right now. This frontline position also highly depends on the fact that classical computers also use superconductors in their architecture, so we are very advanced in making them, and that causes superconductor based qubits to be the cheapest. This is one of the most important reasons why I think superconducting qubits will be the first.

Question 2. Think about the second modality that might be also a good candidate and answer the same as above.

If I had to choose a second best I would take ion trap qubits. Again I think the linear optics qubit is the most elegant but it has too many flaws when compared to the other two. As mentioned ion trap qubits lack the coherence of superconducting qubits, however, they are also scalable and have very high controllability. In comparison with the linear optics it's the same as before. It's much easier to make two ion trap qubits interact than it is for linear optics qubits. And when comparing this to quantum dots, while we get higher speed, the fidelity is very low, thus ion traps have much less losses. One of the main advantages of this modality over superconducting qubits is that they use actual atoms instead of artificial quantum systems. Overall the ion traps are the most stable qubit modality. This stability will help a lot in the construction of quantum computers. While maybe superconducting qubits are faster, it's not always a good idea to go for the best solution, when you don't even have a solution yet. And ion traps can be the less good but working solution for the quantum computer.

Question 3. When do you think the first functional quantum computer will be created? Why do you think it will take the time that you chose to create the first functional quantum computer? Argue at least two reasons.

This question highly depends on the definition of the functioning computer. The way I see it, a functioning computer is the one that can be used instead of a classical computer and get better results while solving a "useful" problem. To get something like this we will need a much higher amount of qubits than we have right now. I'm talking about thousands of qubits. In my opinion, considering that we don't even have the technology to build a computer with a three digit amount of qubits, the functional quantum computer is not as close as some might think. This works for both choices of modalities. However, considering the first choice, I'd say 2030 is a pretty good estimate for the first working prototype of a functioning quantum computer with superconducting qubits. Taking into account the difficulties with the scalability and coherence this rough estimate could be pretty close to the truth. When choosing this year it's taken into account the data we have on the development of the classical computers and the data we have for the superconducting quantum computer development thus far. Comparing these two shows that 2030 is a pretty good estimate for the prototype.

Question 4. Think about the time frame of the second modality that might also be a good candidate. Argue at least two reasons.

The first parts of these two questions are actually the same. All the points made there are valid here too. However ion traps are more stable, which probably makes it easier to build a functioning computer. I think 2035 is a good estimate for the first ion trap functioning quantum computer. It'd probably be possible even earlier than the superconducting one. However, tech giants like IBM , Google , and Intel , all have built their quantum computers with superconducting qubits. This large popularity of superconducting qubits may win them the race.