Assignment - Physics Principles Research

Shaun Pritchard

Rasmussen College

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Arunava Roy

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My current field of study is Computer Data Science. My intended future goal as a grad student will be to seek a research degree in Quantum Computational Science. Both fields are very similar and homogeneous, but classical physics principles are very well endowed in the related fields especially in mathematics, engineering, and electronics. Which all derive principles inherited from physics or quantum mechanics. Physics is based on creating mathematical models of the way the physical universe works. Physics builds on the logic that is integral to computer science. Also, physics and computer science essentially need each other to progress in related fields. Physics is built on the fundamental assumption that we can model the world using algorithms. Hence abstract computations have to be developed to facilitate this exchange by computer scientists and physicists who have experience writing such code.

If we look at the basis of componentry within a computer, we find electronics and physics play a major role. Transistors are responsible for advents and advancements in both physics and computer science *(Solid State Physics (1st ed.), 1976).* A transistor is an electronic component created by joining two types of semiconductors. One type of semiconductor is "P-type" and the other is "N-type" . Transistors work using the same basic principles of their predecessor technology, the vacuum tube *(Mary Bellis, 2019)*. The basic idea of both is to provide some way to toggle the device between an on position and an off position. these physical elements were constructed using principles of physics. John Bardeen was an eminent American physicist, who won the Nobel Prize twice. In 1956, with fellow scientists William B. Shockley and Walter H. Brattain, Bardeen shared the award for the invention of the transistor *(Rossman, n.d).* This was only shortly after Alan Turing who was a mathematician, computer scientist, logician, cryptanalyst, philosopher, and theoretical biologist. Built the Universal Machine also known as the Turing Machine in 1936 *(Biography.com, 2014).*

Many mathematical principles that underlie physics are involved with not only the construction of computational components but also the abstraction in circuit designs which enable computers to receive billions of signals of data per microsecond. It takes a great understanding of mathematics such as basic algebra and the ability to solve simultaneous linear equations to essential to be able to use Kirchoff's and Ohms law which are some of the basic building blocks of simple electronics *(Khan Academy, 2020).* Calculus, discrete mathematics, statistics, and linear algebra are especially useful in Turing based computational and circuit design. Simple derivations of circuit design abstractions with a bit of differentiation or integration threw in. For example, the charge in a capacitor is **Q=CV** where **Q** is the charge, **C** is the capacitance and **V** is the voltage. If you differentiate it concerning the time you get

**dQ/dt = C dV/dt** *(Khan Academy, 2020)****.***

Over the years scientists and physicists have incorporated many new advancements of computation and the underlying circuitry that we all use today. Many physicists and computer scientists have developed new ways to reduce the size of transistors allowing us to fit millions of transistors in circuits that we use as mobile devices *(Zafar, 2019)*. Layered with abstractions, algorithms, and programmed bringing us modern computers that we use today. Today more computational power resides in a mobile device when that which was used to send the first spaceship to the Moon *(NASA, 2013).*

Computer science has a major focus on the design and analysis of computational algorithms. An algorithm in mathematics is a procedure, a description of a set of steps that can be used to solve a mathematical computation. Mathematical modeling is a cornerstone of design complex abstractions in computer science. Many of these modeling principles were adopted from early physicist models *(ThoughtCo, 2018).*

Arguably after the 1890s if we do not include the theories of Democritus *(Aaronson, 2013).* The Theory of Quantum mechanics started to surface in the scientific community. After Albert Einstein rose to world fame with the theory of special relativity which was built upon Newtonian physics *(Nobel Prize, 1921).* Physicists such as Max Planck, Ernest Rutherford, and Niels Bohr started one of the greatest debates of physics in the twentieth century. Max Planck suggested that heat and light come in units that cannot be divided which he called “energy quanta.” This sparked Planck's black-body radiation experiment known as the ultraviolet catastrophe *(Physics.info, n.d).* Planck used the second law of thermodynamics also known as entropy to derive a formula for the experimental results derived from the black-body radiation problem *(Ifrah, 2000).*

**S = k log W**

Planck used Boltzmann’s statistical method to calculate entropy, Planck sought a formula to match the results of the black-body experiment. By dividing the total energy (**e**) in chunks proportional to the frequency (**f**), he came up with the equation:

**e = hf**

Where **e** is a chunk of energy, his known as the Planck constant, and **f** is the frequency *(Guo, 2018).* This essentially went against Boltzmann’s statistical method demanded the chunks decrease to zero over time. Planck found that to absorb or emit energy in a continuous range. It must absorb emit energy in small indivisible chunks of **e = hf** which he called “energy quanta,”

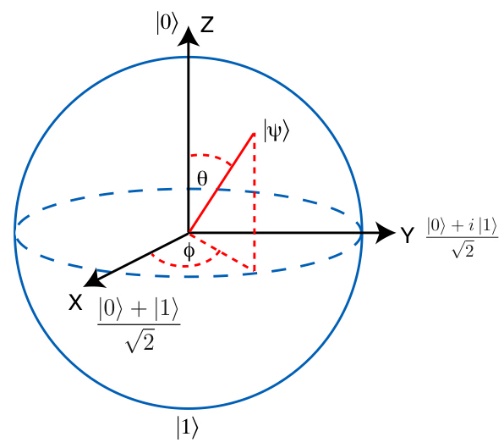
hence the term quantum mechanics. Bohr applied Plank’s groundbreaking idea of energy quanta to the atom, the smallest unit of matter even though he had a tough time describing it. Scientists and physicists such as Werner Heisenberg sought to legitimize Bohr’s view by creating a mathematical description of the atom for what is now known as matrix mechanics. Which led to his uncertainty principle *(APS, 2008).* Then scientists such as Erwin Schrödinger developed the infamous Schrödinger statistical model(equation) which is the underlying basis in modern quantum computation and mechanics *(M.A. Shubin, 1983).* Also, scientists such as Louis de Broglie postulated on Bohr's model finding that those particles also exhibit wave properties and creating duality may be necessary to understand the nature of light *(Libretexts.org, 2019)*.

Albert Einstein would thereafter dismiss quantum entanglement—the ability of separated objects to share a condition or state—as “spooky action at a distance.” Over the past few decades, however, physicists have demonstrated the reality of spooky action over ever-greater distances *(Popkin, 2018).*

Later during the early and mid-twentieth century, many other scientists made groundbreaking contributions. Richard Feynman, probably one of the most renowned physicists who made contributions such as quantum electrodynamics, he developed an important tool known as Feynman diagrams to help conceptualize and calculate interactions between particles in space-time *(Feynman, 1984).*

Quantum computing began in the early 1980s when physicist Paul Benioff proposed a quantum mechanical model of the Turing machine. Richard Feynman and Yuri Manin later suggested that a quantum computer had the potential to simulate things that a classical computer could not *(Longdom, n.d).*

Peter Shore a professor of applied mathematics at MIT. Is known for his work on quantum computation, in particular for devising Shor's algorithm, a quantum algorithm for factoring. Shor's algorithm runs in polynomial time *(Shore, 1997).* Demonstrating that the integer factorization problem can be efficiently solved on a quantum computer. These contributions have to lead to the reality of quantum machines that use Qbits(quantum bits). The quantum version of the classical binary bit is physically realized with a two-state device. We represent th3ese two-state devices using linear algebra and the Bloch sphere *(Mannucci, 2008).*



Essentially without the confines of physics, the contributions thereof, and the convents of mathematical principles developed by physicists, mathematicians, and engineers. Today we would not have the advancements of computational power that we have all come to use in our day-to-day lives. These things would not exist without the foundational principles that physics and mathematics established and provided. Also, my field of study would not exist to the extent that it does today. From software engineering to data science, to artificial intelligence and deep learning. A computer scientist has to be well versed in all subjects including physics. In general, they have to have a firm understanding of complex mathematical principles and abstraction within the physical world to be able to apply those principles through computations as a contributing factor to the rest of the world and many given fields such as physics.

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