

## LECTURE X

# Current Events in Engineering

## **SECTION I**

# **Generative Artificial Intelligence**

# What is Artificial Intelligence?

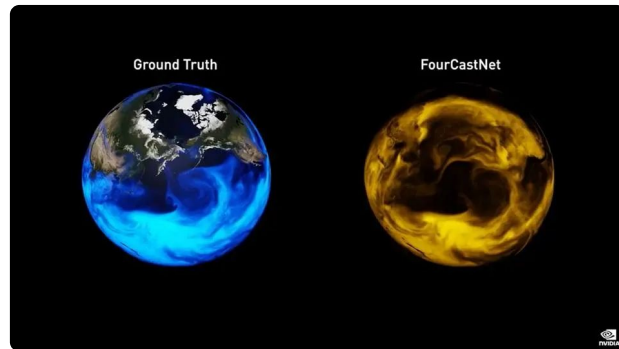
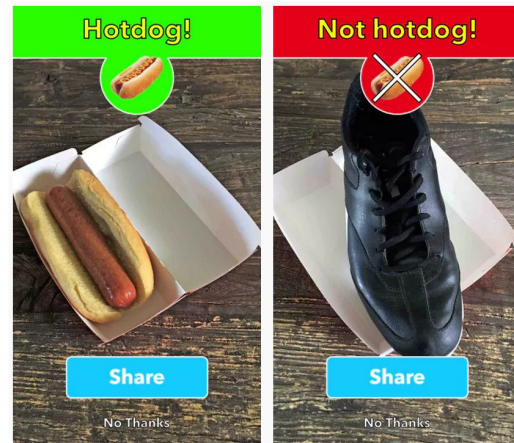
- **Artificial Intelligence (AI)** is technology that **simulates human behavior**
  - Ex) Chess bot, video game NPC, Alexa, Google Maps traffic estimates
- How do I know if a system is AI or not? Yes, if any of the following...
  - Does it learn or adapt to new information?
  - Does it make decisions or predictions based on input data?
- There are different approaches to AI (search algorithms, expert systems), but we will focus on **machine learning** in this lecture...

# Machine Learning

- **Machine learning (ML)** is a process of “training” programs to recognize patterns from data and to make decisions based on those patterns
  - **Programs self-learn** new behavior with some (but not much) human intervention
- **Deep learning** is a subset of machine learning which uses **artificial neural networks** and involves **little to no human guidance**
  - **Neural networks** are ostensibly mathematical functions with coefficients and biases that are adjusted while trained to data
    - Eventually, the neural network (or function) is optimized such that, provided an input, it will generate an accurate output

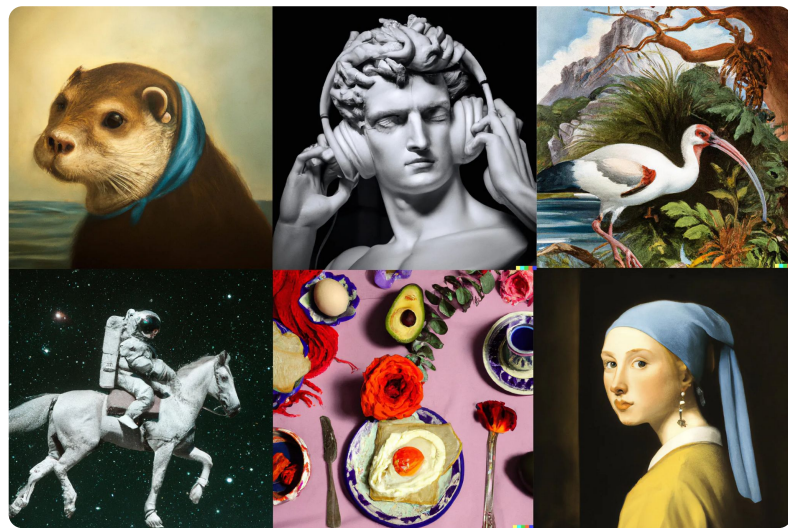
# Predictive Models

- We train **models** (aka programs) which can then be used to **make decisions based on new, unseen data**
- Up until the last few years, we mostly built **predictive models**
  - These models are **used for classifying data**
  - Ex) [Not Hotdog](#) is a predictive model that performs image classification to identify hotdogs in photos
  - Ex) [FourCastNet](#) Weather forecasting



# Generative Models

- More recent breakthroughs led to **generative models** – artificial intelligence that can **generate new content** (text, images, simulations, etc.)
  - Ex) [ChatGPT](#), [DALL-E](#), [Llama](#), [Gemini](#) (all released in 2022)
- From just 2022 to 2024, many of these models have been improved dramatically in realism, size, and speed...



**DALL-E by OpenAI**

# Training ChatGPT

- ChatGPT is powered by **large language models (LLMs)** designed to understand and respond to human language
  - Models like the ones used with ChatGPT are **trained using deep learning**
- Training makes the model more accurate. How?
  - **We feed it data... lots of it**
    - Acquired from information “publicly available” on the internet
    - the exact amount is not disclosed
- The size of GPT-3 (the LLM on which ChatGPT is based) is rumored to be 350GB



# Sora

- Generative AI has arguably surpassed the **uncanny valley** – the idea that virtual or artificially-generated content designed to look real still appears... weird
- In February 2024, OpenAI announced [Sora](#) – a text-to-video generative model
- Here is some example content:





# Generative AI in the Film Industry

- The film industry rapidly adopted the new technology
  - Luke Skywalker's face was rendered with specially-trained "deepfake" generative models in *The Mandalorian*
- Adobe products now feature generative AI tools...
  - Objects can be added or removed on a whim



# AI Risks: Misinformation

- Generative AI does not verify the truthness of its responses
  - The **accuracy of its results are coincidental**, not assured...

● Ex)

The screenshot shows a Bing Copilot search interface. The user's query is "Tell me about Benjamin Bielecki". The Copilot response is titled "Bing Copilot" and says "Certainly! Here's what I found about Benjamin Bielecki:". The results are organized into three sections: "1. Legal Case:", "2. Academic Involvement:", and "3. GitHub Contributions:". The "Legal Case:" section contains a list of bullet points, with the first one highlighted by a red box. The "Academic Involvement:" section also contains a list of bullet points, with the last one highlighted by a blue box. The "GitHub Contributions:" section is partially visible at the bottom. The interface includes a "New topic" button and a search bar at the bottom.

You  
Tell me about Benjamin Bielecki

## Bing Copilot

Copilot  
Certainly! Here's what I found about Benjamin Bielecki:

1. Legal Case:

- Benjamin Bielecki, a 20-year-old man from Lake in the Hills, Illinois, was charged with several serious offenses related to a stabbing incident that occurred on August 13, 2022. He stabbed his mother in the back, leaving her seriously injured.
- The incident took place in the 600 block of Lorree Lane in Lake in the Hills.
- Bielecki was charged with attempted first-degree murder, aggravated domestic battery, aggravated battery causing great bodily harm, and aggravated battery with a deadly weapon.
- His mother suffered "great bodily harm" and sustained a collapsed right lung due to the stabbing.
- Bielecki intended to kill his mother during the attack.
- He was held in the McHenry County Jail on a \$500,000 bond.
- Bielecki entered into a negotiated plea deal with the McHenry County State's Attorney's Office, pleading guilty to one count of aggravated domestic battery. As a result, his other charges were dismissed, and he was sentenced to **60 days in jail**.

2. Academic Involvement:

- Benjamin Bielecki is a computer science engineering senior at the University of California, Irvine (UCI).
- He has been actively involved in the **IEEE at UCI** student organization.
- Bielecki served as the lead instructor for the **Open Project Space (OPS)** program, which provides hands-on experience to students.

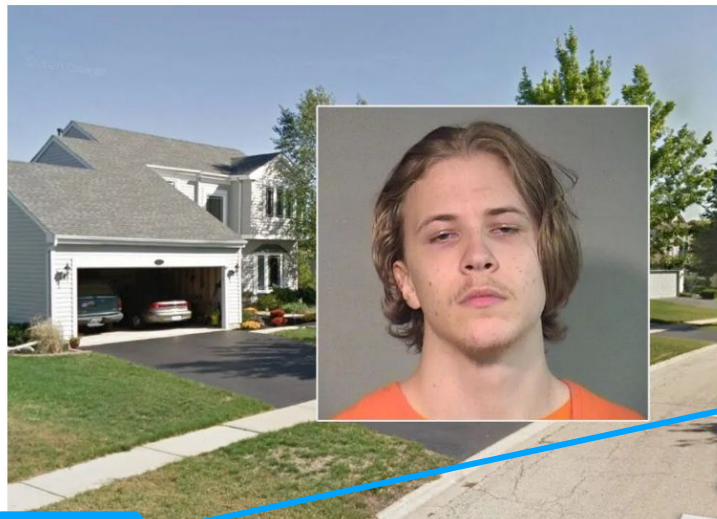
3. GitHub Contributions:

New topic  
Ask me anything...  
0/2000

*"Benjamin Bielecki, a 20-year-old man from Lake in the Hills, Illinois, was charged with several serious offenses..."*

*"...served as the lead instructor for the Open Project Space (OPS) program..."*

# AI Risks: Misinformation (Cont'd)



Anthony J. Bielecki, 19, of Arlington Heights, (inset) is charged in connection with a stabbing that left a woman injured in the 600 block of Cortez Lane in Lake in the Hills on August 13, 2022. | Background Photo: Google Street View

LOCAL NEWS

## 60 days in jail for man who pleaded guilty to stabbing his mother in Lake in the Hills



by Sam Borcia

Published May 27, 2023 9:54 AM

*"...Anthony J. Bielecki, 19..."*

- Generative AI **doesn't "know" what it is saying/showing**
  - It simply **uses math and statistics to predict** the most likely output


# AI Risks: Misinformation (Cont'd)

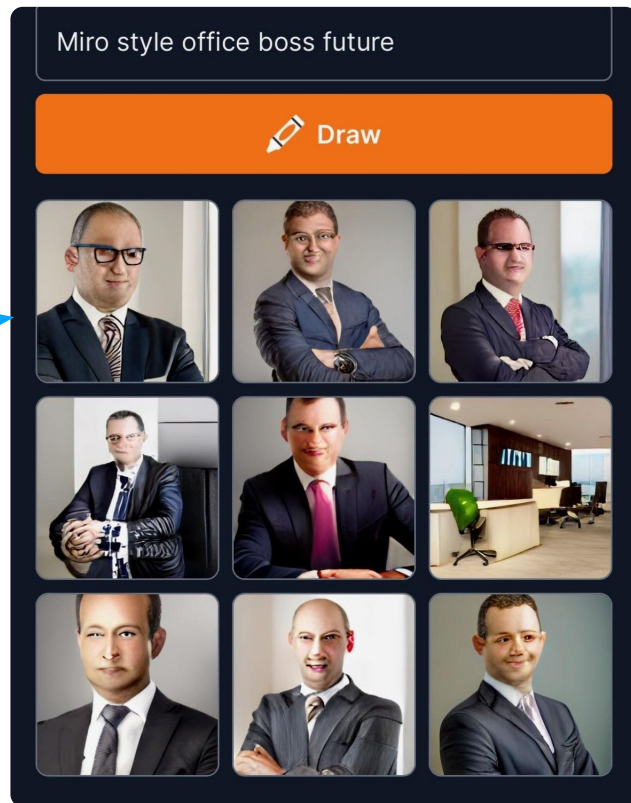
- Tech news outlet **CNET** was discovered to have used **AI to write stories**
  - Corrections had to be issued to 41 of the 77 stories where AI was used
- LLM tools are known to have generated **false attributions**
- Prevalence of **AI fake news sites** has dramatically increased
  - Bad actors create sites to generate *intentionally* misleading content
- **Deepfakes** – fake imagery of real people – can be used to spread false information

# AI Risks: Intellectual Property

- The **New York Times** filed a lawsuit against **Microsoft** (owner of ChatGPT)
  - Alleges that **chatbots are violating the IP rights** of the Times by plagiarizing their articles verbatim
  - The bots generate false attributions to the Times
  - There are suits from fiction and nonfiction authors as well over IP rights violations
- Amazon and other large companies inform employees not to share code or information with ChatGPT
  - **Proprietary code could be used as training data** or mixed with other company's IP

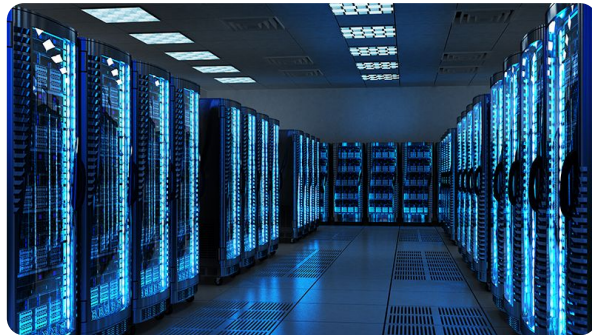
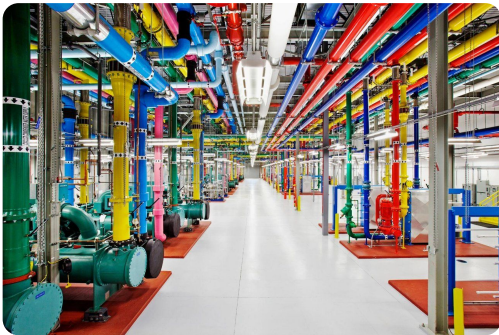
# AI Risks: Bias

- The **training data can introduce bias** based on race, sex, etc.
  - If the training data is not robust, the model will be less accurate
  - Are all CEOs White men? 
- Computer-aided diagnosis systems have **lower accuracy results for Black patients** than White patients



# AI Risks: Environment

- Data centers which power AI tools **require lots of water** for cooling
  - Microsoft's global water consumption increased by 34% from 2021 to 2022 due to its AI Research
- Servers also **require significant power**
- AI and the cloud are **expected to intensify greenhouse gas emissions**



# AI Revolution

- Generative *and* predictive models are rapidly changing all industry sectors...
  - **Journalism** – News reports are increasingly generated with AI tools
  - **Healthcare** – AI will conduct health interviews, identify diseases, and monitor patient stats
  - **Finance** – Stock trades, fraud detection, and financial audits will all be automated
  - **Transportation** – self-driving vehicles, traffic light optimization, future urban planning
  - The list goes on...



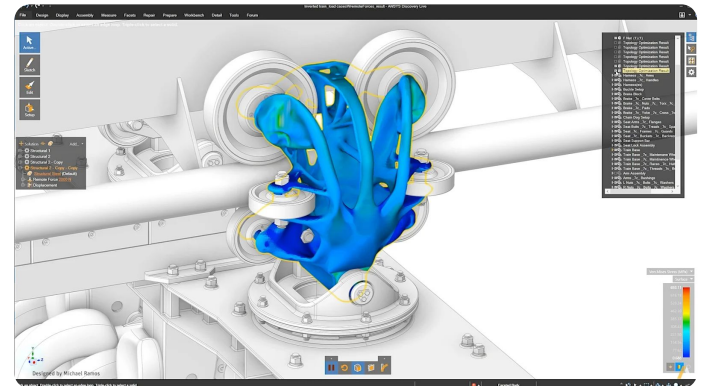
# AI Revolution: Software Development

- Software engineers are already using **generative AI coding tools**, which can...
  - Explain code functionality
  - Simplify code
  - Write unit tests
  - Write documentation
  - Identify bugs
- These tools are **not competent enough to write full software applications**
  - This won't leave programmers unemployed (maybe the bad ones)
- [Learn prompt engineering](#) to take advantage of these tools and write new ones!



# AI Revolution: Mechanical Engineering

- Engineers can use **generative design** software to create structures and systems
- Generative design tools are useful for...
  - Quickly generating several **permutations of structures** based on design constraints
  - creating **complex shapes which cannot be traditionally manufactured** (using additive manufacturing)
  - **design optimization**

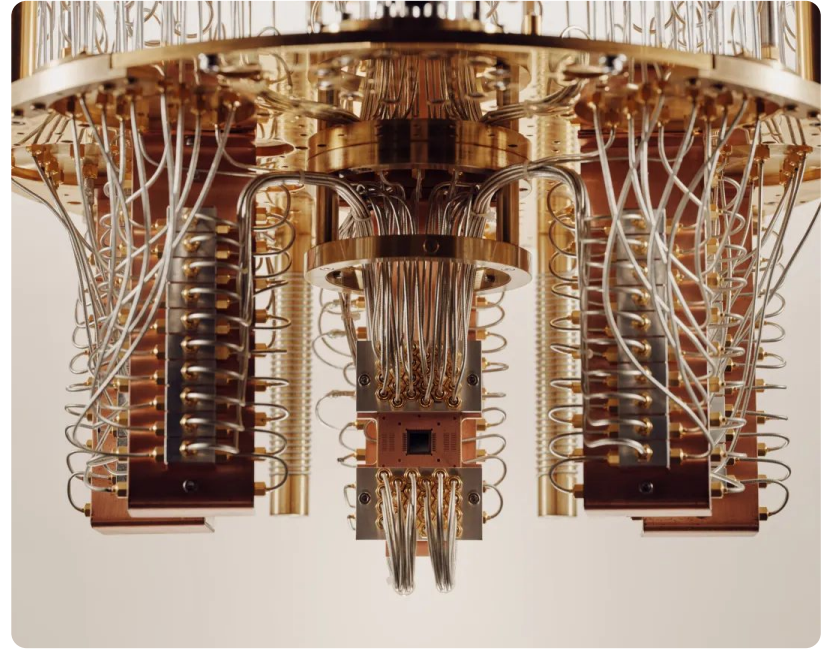


## SECTION II

# Quantum Computing

# Quantum Computers

- **Quantum computers** are specialized hardware and software that utilizes quantum mechanics (physics at the subatomic level)
- This lecture focuses more on why quantum computing is important, not how it works



**IBM Q System One**

# Qubits

- Data is represented as **quantum bits (qubits)** on quantum computers instead of classical bits
  - They **can represent a 1 or 0**, like classical bits OR...
  - They can **also be in a superposition of 1 and 0**, with a certain probability of being 0 and a certain probability of being 1

**Bit**  
(Classical Computing)

0



1

**Qubit**  
(Quantum Computing)

0



1

# Superposition and Entanglement

- What makes qubits so useful?
- The principle of **superposition** enables qubits to **exist in multiple states at once**
  - Classical bits only exist in one state at a time
  - **Qubits store more information** than a classical bit while in superposition
- Multiple qubits can experience **entanglement**
  - In entanglement, the **qubits' states correlate**
  - We can **manipulate many qubits** just by changing one qubit **in a single operation**

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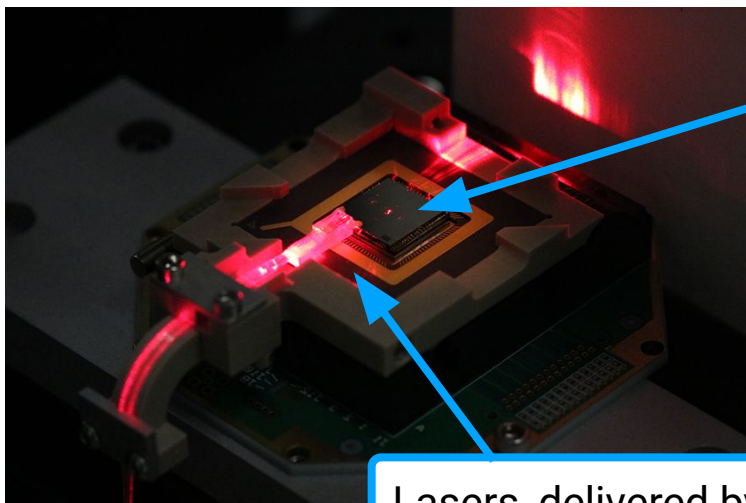
# Implementing a Qubit

- Qubits can be made from **trapped ions, electrons, real or artificial atoms**
  - Some implementations demand **temperatures approaching absolute zero** (to shield from magnetic and electric interference)
- Ex) **Ion Trap Qubit**
  - A charged atom (ion) is **trapped by electron fields** and **cooled to near absolute zero** (low energy)
  - **Lasers** are used to **change the energy state** of the qubit
  - **Lasers and cameras** are also used on the ion to **measure the qubit** state

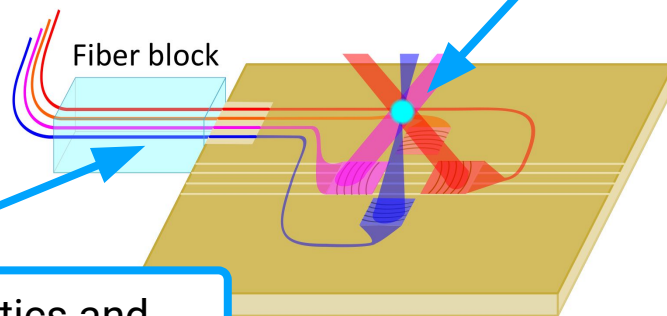


# Implementing a Qubit

Below is an implementation of the **ion trap qubit on a chip**:



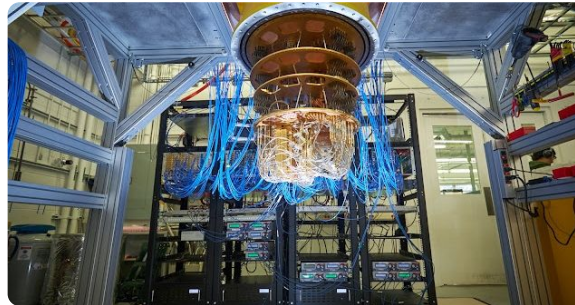
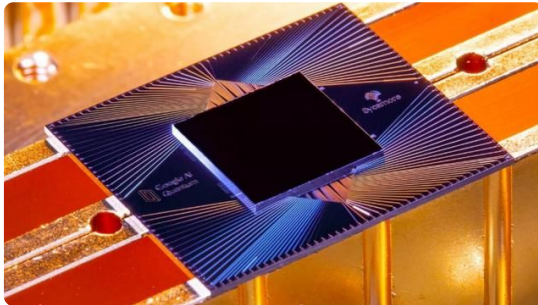
An ion is trapped just above the chip's surface at cryogenic temperatures



Lasers, delivered by fiber optics and guides within the chip, control the ion qubit

# Quantum Computing Speeds

- The qubit's superposition and entanglement properties enable **extremely fast computing**
  - *"Information that 500 qubits can easily represent would not be possible with even more than  $2^{500}$  classical bits."* – Microsoft
- **Google's Sycamore processor** (53 qubits) was used to **complete a task in 200 seconds** that would take a state-of-the-art supercomputer 10,000 years



# Where is Quantum Computing Heading?

- Quantum computers **need to be brought to scale**
  - Computers require thousands of qubits to perform tasks useful to humans
    - **Most today are less than 100 qubits**
  - Management consulting firm McKinsey estimates that the technology for handling complex problems won't be available before 2035
- **Quantum computers are error-prone** due to environmental noise to imperfections in the qubits
  - **Quantum Error Correction (QEC)** is being developed to handle this
- One of its most immediate effects has been on cybersecurity...

# Cryptography in the Quantum Age

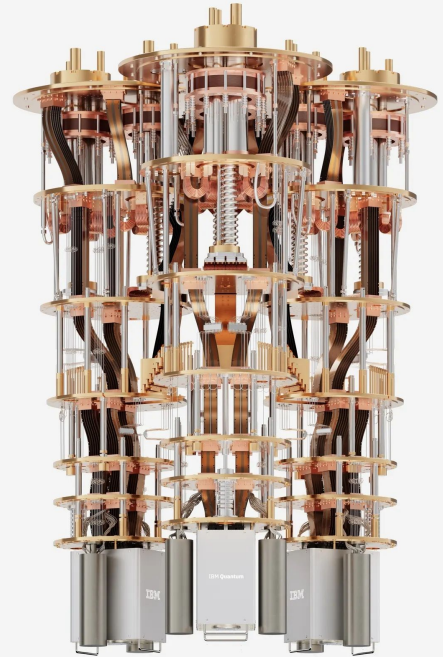
- **Cryptography** is the study of technique for secure communication
  - **Private information is encrypted** so it may only be decrypted by trusted people and not be read by bad actors
  - There exist methods of encryption, data transfer, and decryption
- **Over 90% of the Internet uses RSA encryption** (Forbes)
  - Relies on the fact that it would be **prohibitively time consuming to break the encryption**
  - Shor's Algorithm suggests **quantum computers could solve RSA encryption fast**, making it entirely unsafe

# Cryptography in the Quantum Age

- **Quantum Key Distribution (QKD)**
  - Most viable method of quantum cryptography so far
  - Allows private data to be transmitted in a way that makes **undetected eavesdropping impossible**
  - Considered impractical due to scalability issues and security concerns – chiefly, how do you authenticate the connection?
- The **U.S. National Institute of Standards and Technology (NIST)** has announced several **quantum-resistant cryptographic algorithms**
  - These do not require quantum computers

# Advancing Quantum Computing

- Google, IBM, Microsoft, and Amazon are some of the top companies researching quantum computing
- IBM is leading the quantum race
  - The **IBM Condor** is the first quantum processor to exceed 1,000 qubits (December 2023)
    - 1,121 qubits



# Quantum Computing Jobs

Here are “hypothetical” 2024 job listings with the qualifications employers are currently looking for...

## Quantum Research Scientist (Shmamazon – Pasadena, CA)

### Basic Qualifications

- PhD or Master's
- 4+ years of quantitative research experience

### Preferred Qualifications

- R, MATLAB, Python
- Agile development experience

## Quantum Systems Architect (Shmicroshmoft – Washington)

### Qualifications

- BS/MS in CS or related field
- 5+ in the software industry
- 3+ years with Azure

Notice that these jobs **do not always require prior quantum computing experience**

## **SECTION III**

# **Final Thoughts**



# How to Keep Up

There will always be newly emerging technologies. So how do you stay current?

- **Join a professional organization** (pssst... IEEE)
  - You receive access to publications, conferences, and chapter events that update you on current events
- **Attend conferences and tech events**
  - Attend workshops and classes at events like IEEE Rising Stars
- **Read the news and listen to podcasts**
- **Commit time to personal projects**
  - [You can learn machine learning](#) right now!

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