**Quantum Computing**

# **Objective:**

## Through this outline I hope to frame the history leading up to the current state on Quantum Computing.

# **Introduction:**

## Quantum Mechanics

### the branch of mechanics that deals with the mathematical description of the motion and interaction of subatomic particles, incorporating the concepts of quantization of energy, wave-particle duality, the uncertainty principle, and the correspondence principle.

## Quantum computing

### a type of computation that harnesses the collective properties of quantum states, such as superposition, interference, and entanglement, to perform calculations. The devices that perform quantum computations are known as quantum computers

### Qubit

#### The basic unit of information in a quantum computer

#### Unlike the classic “bit” which stores information as 1s or 0s, the qubit is in a superposition state, which allows it to be both 1 and 0.

#### Operate simultaneously in every potential state until observed.

### Hardware required to run quantum calculations

#### Temperatures near 0K

#### Chips required

##### *Quantum Processor*

##### *Quantum Reversal Logic Gate*

##### *Quantum register*

##### *Integration with classical computers*

##### *User based software*

## Discuss the history of Quantum Computing.

### 1980 Paul Benioff proposed a quantum mechanical model of a Turing machine

### 1994 Peter Shor developed a quantum algorithm that was used in factoring integers

### 1998 Isaac Chuang, Mark Kubinec & Neil Gershenfeld create world’s first two-qubit quantum computer.

### 2004 the first quantum road map was developed

#### last updated 2009

### 2018 US signs into legislation the Quantum initiative act

### By 2022 there is 15 countries actively working toward quantum research

## Discuss the benefits of Quantum Computing

### Ability to calculate large data

### Ability to simulate 1000x faster than classical computers

### Allows for operations previous though impossible

### instantaneous information transfer

### CERN data analysis

### Able to limit required testing in the lab

# **Countries that are currently investing in Quantum Computing**

## Asia

### China

#### Considered the leader in Quantum Computing, they currently have a quantum satellite in orbit, and the largest land-based quantum communications network established.

#### $10 billion invested

### India

#### Officially joined the Quantum race in 2020

#### Became a real player after launching its QSim toolkit (Quantum Computer Simulator Toolkit) in September 2021

#### The government has helped fund over $1 billion in research

#### India does not create enough parts required in quantum computing locally, creating a lag in development while investing in the required hardware internally.

### Israel

#### Later 2019 invested $400 million into a 5-year Nation Quantum Initiative

#### $60 million towards building country’s first quantum computer

#### More than 60% of funds allocated to academia

### Japan

#### Around $700 million invested

#### July, 2021 University of Tokyo & IBM started operations on Japan’s first commercial Quantum Computer

#### January, 2022 Announced by Toshiba, Nomura Holdings, & NEC, quantum cryptography has been used to transmit stack trading data

### Russia

#### $663 million invested

### Singapore

#### $109 million invested

### South Korea

#### $37 million Invested

### Taiwan

#### $282 million invested

## Australia

### Australia

#### $98.5 million invested

### New Zealand

#### $35.75 million invested

## Europe

### Austria

#### $127 million invested

### European Union

#### $1.1 billion invested

### France

#### $2.2 billion invested

### Germany

#### $2.4 billion infrastructure invested

### Netherlands

#### $904 million invested

### United Kingdom

#### $1.3 billion invested

## North America

### Canada

#### $2.2 billion infrastructure invested

### United States of America

#### $1.2 billion infrastructure investe

#### Considered the antithesis to China’s leading research

#### First to achieve a 3 node quantum entangled network

# **Companies Currently developing Quantum Computers:**

## Intel – Working in collaboration with Qutech.

## IBM – Focused on advancing Universal Gate Models. Partnership with CERN

## ColdQuanta – Used by NASA’s Cold Atom Laboratory

## 1Qbit – Focusing on APIs and variety of algorithms helping bridge the gap between regular computing and quantum computing.

## IONQ – Hardware based ion trapping technology, that allows laser beams to store, process and retrieve information from trapped atoms. They had a new discovery which they published on 02/09/2022

## Isara – Focusing on Quantum Security systems.

## D-Wave – Providing cloud based access to quantum resources.

# **Discuss experiments using quantum principals:**

## The first Quantum entangled network, set up with 3 nodes – Achieved by QuTech.

## Quantum Communications & Simulations

# **Discuss some of the challenges of quantum computing in its current state:**

## Slow advancement in technologies.

## A lot of speculative research.

## Currently in what’s considered a “toddler” state.

# **Discuss the future potential of Quantum Computing:**

## Network Security.

## Space flight.

## Quantum Computers in Consumer Hands.