

1st
Edition

SCIENCE & TECHNOLOGY

FOR UPSC CSE & STATE PCS EXAMS

From the Editorial Board

Dear Aspirants,

We are incredibly grateful for the wonderful response we received for our Polity, History, Economy, and Geography books. Inspired by this positive feedback, we are thrilled to announce the release of the First edition of our book titled 'Science and Technology'.

Science and Technology has gained prominence in the UPSC examination, both in Prelims and Mains stage. Its weightage in the exam has been steady; despite this, there is a dearth of consolidated and updated material on the same subject. Students have to rely on multiple sources making their preparation more difficult.

This book was created taking into account the concern and challenges which the students face during preparing for the subject. The book aims to tackle all these problems, and along with this, it improves students' knowledge base thus saving their precious time and eliminating many academic misunderstandings that they encounter.

Special Features of this Book

This book aims to make your preparation focused and relevant based on UPSC's current trend and pattern, it is revision-friendly, and up-to-date.

- The most highlighted feature of this book is that, that we have given General Science (Biology, Physics, Chemistry) in this book so that aspirants do not have to refer different resources and waste time in searching different sources.
- More than 100 pages of FREE Science and Technology, UPSC focused web content in the form of QR Code in the book. Scan them to access it free of cost.
- The requirements of the UPSC Civil Services Examination are the exclusive focus of this book.
- We have taken great care to ensure that the materials are written in a clear and easy-to-understand, so that students may learn and recall the concepts to their advantage.
- Wherever necessary, we've incorporated diagrams and pictorial representation of various technical concepts to make learning interactive and easy.
- We have incorporated the relevant previous year's questions at the end of each chapter so that the students can test their knowledge while understanding the trend of the question.

With all sincerity and humility, the Study IQ team wishes you the best in your preparation, and we hope this book will help you in your journey.

Detailed Table of Contents

UNIT 1 : GENRAL SCIENCE		
1. Cell Nucleic Acid and Cell Division	2	
• Cell	2	
• Cell Division	10	
• Notes and References	12	
2. Biomolecules and Metabolites	13	
• Biomolecules	13	
• Carbohydrates	13	
• Amino Acids	15	
• Proteins	15	
• Enzymes	16	
• Fats	17	
• Primary and Secondary Metabolites	20	
• Micronutrients	21	
• Essential Micronutrients	22	
• Food Sources of Some Micronutrients	23	
• Notes and References	23	
3. Tissues of Living Being	24	
• Animal Tissue	24	
• Plant Tissue	27	
• Notes and References	29	
4. Systems of the Human Body	30	
• Nervous System	31	
• Muscular System	35	
• Skeletal System	36	
• Respiratory System	40	
• Circulatory System	43	
• Immune System	45	
• Lymphatic System	46	
• Digestive System	48	
• Endocrine/Exocrine System and Hormones	51	
• Excretory System	52	
• Reproductive System	54	
• Notes and References	56	
5. Diseases	57	
• Classification of Diseases	57	
• Causes of Diseases	58	
• Stages of Diseases	59	
• Microbes or Microorganisms	60	
• Acute and Chronic Diseases	67	
• Communicable Diseases	67	
• Organ-Specific and Tissue-Specific Diseases	67	
• Anti-Microbial Resistance	68	
• Useful Microbes	71	
• Cancer	71	
• Human Immunodeficiency Virus HIV / Acquired Immuno Deficiency Syndrome (AIDS)	74	
• Tuberculosis	75	
• Notes and Reference	76	
6. Biological Classification	77	
• Theories about life on Earth	77	
• Evolutionary history of vertebrates through geological period	79	
• Origin And Evolution of Man	80	
• Biological classification of Plants and Animals	80	
• Plant kingdom	87	
• Basis of Classification	90	
• Classification of Animals	91	
• Vertebrata	94	
• Different class in the Animal Kingdom	94	
• Difference between various class of the Animal Kingdom	96	
• Insectivorous plants	96	
• Source	98	
7. Plant Seed and Nutrition	99	
• Plants Seeds	99	
• Plant parts and their functions	102	
• Plant Nutrition	104	
• Notes and References:	108	
8. Atom	109	
• Atom	109	
• Evolution of Atomic Theory	110	
• Difference Between Atomic Mass And Mass Number	111	
• Isotopes	112	
• Isobars	112	

• Element	113	13. Sound	145
• Compound	114	• Sound	145
• Molecules	115	• Simple harmonic motion	145
• Atomicity	116	• Sound Wave	146
• Types of Atomicity:	116	• Propagation of Sound	147
• Ion	116	• Speed of Sound In Different Media	148
• Valency	116	• Reflection of Sound	149
• Molecular Mass and Mole Concept	117	• Range of Hearing	151
• Notes and References	117	• Notes and References	153
9. Metal and Mining	118	UNIT - 2 : SCIENCE AND TECHNOLOGY	
• Metal	118	14. Science and Technology in India	158
• Minerals	119	• Introduction and Evolution of Science and Technology	158
• Ores	120	• Science and Technology during Five Year Plans	167
• Metal & Minerals Mining and Extraction from Ores	120	• Science, Technology and Innovation Policy Documents	179
• Electrochemical Metallurgy	122	• Science and Technology under Various Department and Institutions	193
• Rare Earth Elements (REE) and its strategical importance	122	• Notes and References	199
• Notes and References	125	15. Achievements of India in Science and Technology	200
10. Mechanics	126	• Ancient Indian Contributions to Science and Technology	200
• Classical Mechanics	126	• Modern Scientific Developments in India	204
• Quantum Mechanics	128	• Notes and References	222
• Current research and development	130	16. Concerns in Science and Technology	223
• Difference between Quantum and Classical Mechanics	131	• Draft National Science Technology and Innovation 2020	223
• Standard Particle Model of Quantum Mechanics	131	• Impediments to the Development of Science and Technology in India	224
• Quantum Field Theory	132	• Research and Development Ecosystem in India	227
• National Quantum Mission	133	• Famous Women Scientists Of India	241
• Notes and References	133	• Notes and References	245
11. Fundamental Forces of Nature	134	17. Space Technology	246
• Understanding the Four Forces	134	• Background	246
• Gravitational tidal field	135	• Significance of Space Sector for India	247
• Differences between gravitational and electromagnetic radiation	136	• Issues with Indian Space Sector	248
• Fifth Fundamental Force and puzzling orbits of dwarf galaxies	136	• Steps to strengthen Indian Space Sector	249
• Notes and References	137	• Steps taken by the Government	250
12. Optics	138	• India's Space Research Programme	251
• Geometrical optics	138	• Major achievements in Space Research in India	252
• Reflection and refraction	139	• Organizational Structure of Space Research Governance in India	253
• Optical systems	139		
• Applications of optics in daily life	142		
• Notes and References	144		

• Important organisations related to Space Sector in India	254	• Indian Nuclear Triad Capability	320
• Space Related Policies and Guidelines	259	• Indian Air Force	323
• Types of Orbits	263	• Other Developments	325
• Satellite-Based Internet Connectivity	265	• Indian Defence Sector and Artificial Intelligence	326
• Quantum Key Distribution by Micius	266	• Notes and References	326
• Transponders	267	19. Nuclear Technology	327
• The Unicorn: Smallest-Known Black Hole in the Milky Way	268	• Generation of Nuclear Energy	327
• Event Horizon	269	• Economics of Nuclear Power	328
• P172+18 Quasar	270	• India's Nuclear Research Programme (NRP)	328
• Satellite Technology and Satellite Program	270	• Organisational Structure	330
• INSAT (Indian National Satellite) programme for Communication Satellites	270	• International Mechanism	331
• Indian Remote Sensing programme for Remote Sensing Satellite	271	• Nuclear Power Plant	332
• Satellite Navigation Program	274	• Nuclear Power in India	334
• GAGAN	277	• India's three stage nuclear programme	336
• Space Science and Exploration	278	• India-US Civil Nuclear Agreement 2005	339
• Joint Lunar Polar Exploration Mission	285	• Nuclear Non Proliferation and Disarmament	341
• Venus Orbiter Mission: Shukrayaan	286	• Various nuclear disarmament treaties	341
• Small Satellites	286	• Miscellaneous	344
• University/ Academic Institute Satellites	288	• Multilateral Non-Proliferation Export Control Regimes	344
• Experimental Satellites	288	• Nuclear Liability Insurance	346
• Launch Vehicle & Related Technology	288	• Nuclear Accidents	350
• PSLV	289	• Reason behind Nuclear Energy Opposition	353
• GSLV,	291	• Nuclear Waste	354
• Future of ISRO Launcher	293	• Emergence of alternative to Nuclear Energy	356
• SRE – 1 (Space Capsule Recovery Experiment)	295	• Clean-Energy Alternatives to Uranium	357
• Humans in Space Policy	295	• Pokhran I: Operation Smiling Buddha	358
• Space Diplomacy of India	296	• India's Nuclear Doctrine	362
• Comparative Study of Various Space Missions of Various Space Agencies	305	• Green Light for China's first Thorium - powered nuclear reactor	365
• Notes and References	308	• Zaporizhzhia Nuclear Power Plant	367
18. Defence Sector of India	309	• SIPRI Yearbook 2023 & Nuclear Arsenal	367
• About the Defence Sector in India	309	• New Uranium Isotope Discovered	368
• Historical Background	309	• Japan adopts new policy on Nuclear Energy	369
• Organisational Set-Up And Functions	310	• Experimental Advanced Superconducting Tokamak (EAST)	370
• Missile Programme of India	311	• National Technology Day	370
• Indian Ballistic Missile Defence Programme	315	• Natanz: Iran's Subterranean Nuclear Facility	371
• Cruise Missiles	316	• Notes and References	372
• Anti-Satellite (ASAT) Missile Test mission Shakti	317	20. Information Technology	373
• Difference between Cruise and Ballistic Missiles	317	• Background	373
• Indian Navy	318	• Need for Information Technology	373
		• Development of IT technology	374

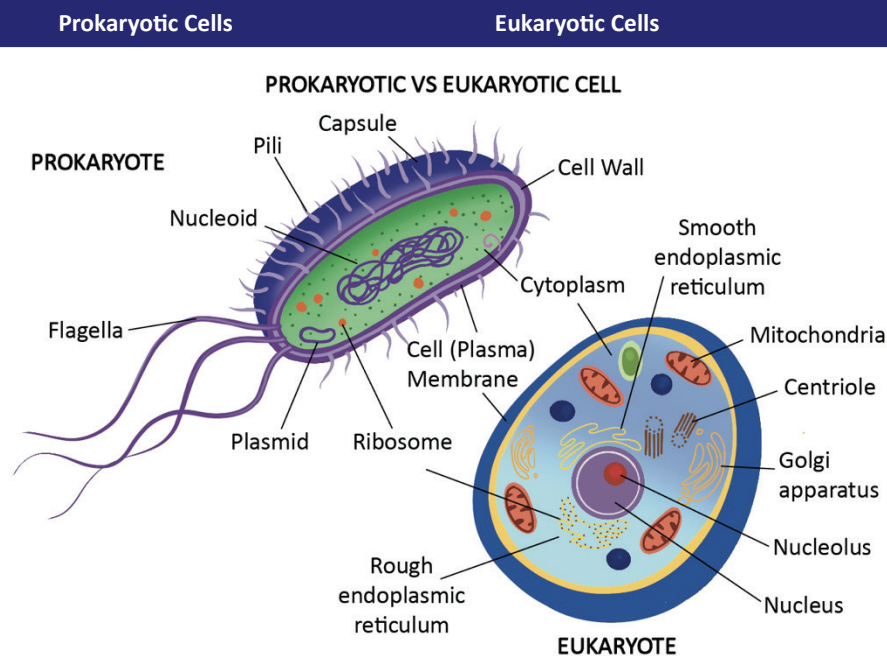
• Information Technology Development in India	375	• Biotech Regulatory Agencies in India	451
• Institutions related to IT in India	377	• Tools of biotechnology	455
• Various Acts Related to IT Sector in India	377	• Application of biotechnology in various fields	457
• Limitations of IT sector of India	379	• Biotechnology related Policy developments in India	459
• Policies Related to IT Sector in India	380	• Coronavirus and its origin	465
• Programs related to the Promotion of IT in India	381	• Generic medicine	470
• Broadband and Significance of Broadband Technology	382	• Alternative medicine	474
• Bharatnet	383	• Reproductive Technologies	477
• Location-based service (LBS)	386	• Assisted Reproductive Technology (Regulation) Bill, 2020	479
• High-Definition Television	388	• Commercial Surrogacy	481
• DTH Broadcasting Technology	390	• The Surrogacy (Regulation) Bill, 2019	482
• Networking	391	• Three Parent Baby	483
• Cloud Computing	394	• Genome Sequencing	484
• Threats to Computers	396	• DNA Fingerprinting (DF)	485
• Cyberwars	397	• Pharmaceuticals	487
• Artificial Intelligence (AI)	399	• National Biopharma Mission	487
• ChatGPT	401	• Clinical Trials	488
• Draft National Strategy for Artificial Intelligence	402	• Antimicrobial Resistance (AMR)	488
• Big Data	407	• Biotech-Kisan Scheme	490
• Data center ecosystem	410	• Plant Genomics and Genotyping Facility	491
• Draft Data Center Policy 2020	411	• National Centre for Microbial Resource (NCMR)	492
• Draft Data Protection and Empowerment Architecture	413	• Cattle Genomics Programme	493
• Internet of Things (IoT)	416	• Biotech Science Clusters	494
• Blockchain Technology	422	• UNaTI (Undertaking Nationally Relevant Technology Innovation) Mission	495
• Free Space Optical Communications	428	• Reducing Risk of Zoonoses in Food Production	497
• Quantum Computing	430	• Research on Cell-based Meat	499
• VR, AR, MR	432	• Manav: Human Atlas Initiative Gold Coated Fungi	500
• 3D Printing	436	• Miscellaneous	500
• Cell Phone Technology	439	• Notes and References	504
• Megapixel	441		
• Biometric Recognition Technology	441		
• Notes and References	444		
21. Biotechnology	445	22. Nanotechnology	505
• Background	445	• Evolution Of Nano Technology	505
• Significance of Biotechnology	446	• Basics of Nanotechnology:	506
• Current Situation of Biotech Industry at Global and Domestic Level	447	• Properties of Nanomaterials	507
• Reasons for growing biotech industry	447	• Applications of Nano technology	509
• Types of Biotechnology	448	• Uses of Nanotechnology	509
• Color Coded Classification of Branches of Biotechnology	450	• Challenges, Risks and Ethical Issues	511
• Ethical and Non-Ethical Dilemma of Biotech	450	• Nanotechnology Research in India	511
		• Recent Development	512
		• Nanobubbles	513
		• Notes and References	516

23. Semi-Conductor and Laser Technology	517	24. Intellectual Property Rights	532
• Semi-Conductor	517	• Intellectual Property Rights (IPR)	532
• Semiconductor Industry in India and around the Globe	518	• Types of Intellectual Property	535
• Types of Semiconductors	519	• TRIPS Agreement	540
• Applications of Semiconductor Devices	520	• World Intellectual Property Organisation	546
• Semiconductor Research in India	520	• Different types of Intellectual Property Rights in India	549
• LASER	521	• Traditional Knowledge	559
• Helium - Neon Laser	522	• National IPR policy, 2016	564
• Application of LASERs	524	• Cell for IPR Promotion and Management	568
• LIDARs	525	• Notes and References	571
• Anti-Laser and its application	526		
• Recent Developments	527		
• Semiconductor Quantum Dots	528		
• Chip 4 Alliance	528		
• Notes and Reference	531		

SAMPLE PAGES

- These organisms are grouped into the biological domain of Eukaryota. Eukaryotic cells are larger and more complex than prokaryotic cells.
- The transfer of nutrients and electrolytes into and out of the cells is observed by the plasma membrane. Additionally, it is in charge of cell-to-cell communication.
- They can reproduce both sexually and asexually.
- Plant and animal cells have some distinct differences. For instance, whereas animal cells lack chloroplasts, central vacuoles, and other plastids, plant cells do.

Difference Between Prokaryotic and Eukaryotic Cells



Meaning of name	Pro = primitive/before Karyon = nucleus	Eu = new/after Karyon = nucleus
Uni-/multicellular	Unicellular (less complex)	Multicellular (more complex)
Evolution	3.5 billion years ago (older type of cell)	1.5 billion years ago
Organelles	Generally, none	Various ones with specialized functions
Cell wall	almost all have (murein)	fungi and plants (cellulose and chitin): none in animals
Metabolism	anaerobic and aerobic	mostly aerobic
Genetic material	Single circular double-stranded DNA	Complex chromosomes are often found in pairs, with each containing a single double-stranded DNA molecule and any associated proteins in the nucleus.
Organisms	Eubacteria and Arche bacteria	Protists, Fungi, Plants and Animals
Location of genetic information	Nucleoid region	Nucleus
Mode of division	Binary fission mostly; budding	Processes of mitosis and meiosis. Mitosis is common to all eukaryotes.

	Molecule	Element
Break	Can be broken down by chemical means.	Cannot be broken down by chemical means.
Bond	Have either covalent bonds or ionic bonds	Can form different types of chemical bonds depending on electron configurations and stability
Atomic number	Contain a unique atomic number	Can be either homo-nuclear or Hetero-nuclear
Example	Carbon dioxide, water, and ozone	Hydrogen, oxygen and copper.

● ATOMICITY

Atomicity refers to the **number of atoms present in a molecule of a substance**. For eg.

- Atomicity of oxygen(O_2) is 2, Atomicity of ozone(O_3) is 3.
- NH_3 (Ammonia) has one nitrogen atom and three hydrogen atoms. Thus its atomicity is $1+3=4$.

● TYPES OF ATOMICITY:

Monatomic atomicity

Some substances exist as **molecules made up of just one atom**, such as noble gases like helium, neon, and argon. These substances are said to have a monatomic atomicity.

Diatomic atomicity

Other substances exist as **molecules made up of two atoms of the same element**, such as oxygen gas (O_2) or nitrogen gas (N_2). These substances are said to have a diatomic atomicity.

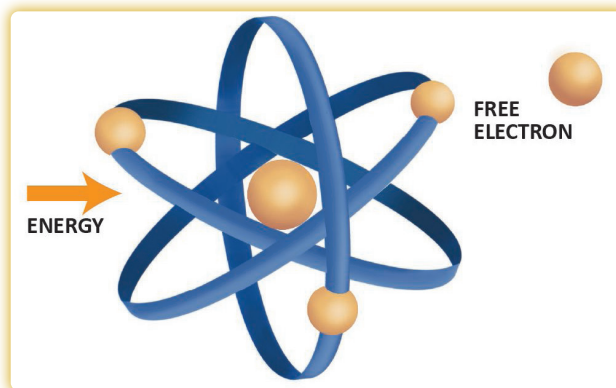
Polyatomic atomicity

There are also substances that **exist as molecules made up of three or more atoms**, such as ozone (O_3) or sulfuric acid (H_2SO_4). These substances are said to have a polyatomic atomicity.

The atomicity of a substance can have an **effect on its physical and chemical properties**. For example, **diatomic gases like oxygen and nitrogen have different physical properties than monatomic noble gases**. Additionally, polyatomic molecules can have more complex chemical reactions and can often act as acids or bases due to the presence of multiple functional groups.

An ion is an **atom or a molecule that has a net electrical charge** because it has gained or lost one or more electrons. An ion that has lost electrons and has a positive charge is called a **cation**, while an ion that has gained electrons and has a **negative charge is called an anion**.

● ION



When an atom loses one or more electrons, it becomes positively charged because the number of protons in the nucleus is greater than the number of electrons in the electron cloud surrounding it. For example, a **sodium atom with 11 electrons can lose one electron to become a sodium ion with a positive charge of +1**.

When an atom gains one or more electrons, it becomes negatively charged because the number of electrons in the electron cloud is greater than the number of protons in the nucleus. For example, a **chlorine atom with 17 electrons can gain one electron to become a chloride ion with a negative charge of -1**.

Ions are essential in many chemical reactions and biological processes. For example, the transport of ions across cell membranes is critical for **nerve impulses, muscle contractions, and many other physiological functions**.

● VALENCY

Valency⁽²⁾ refers to the **number of electrons an atom can gain, lose or share to achieve a stable configuration**. In other words, valency is a measure of the combining power of an element, and it determines the type and number of chemical bonds an element can form with other elements to create a molecule or a compound.

Board of Governors:

- It is one of the two policy-making bodies of the IAEA, along with the annual General Conference of IAEA Member States.

IAEA Safeguards:

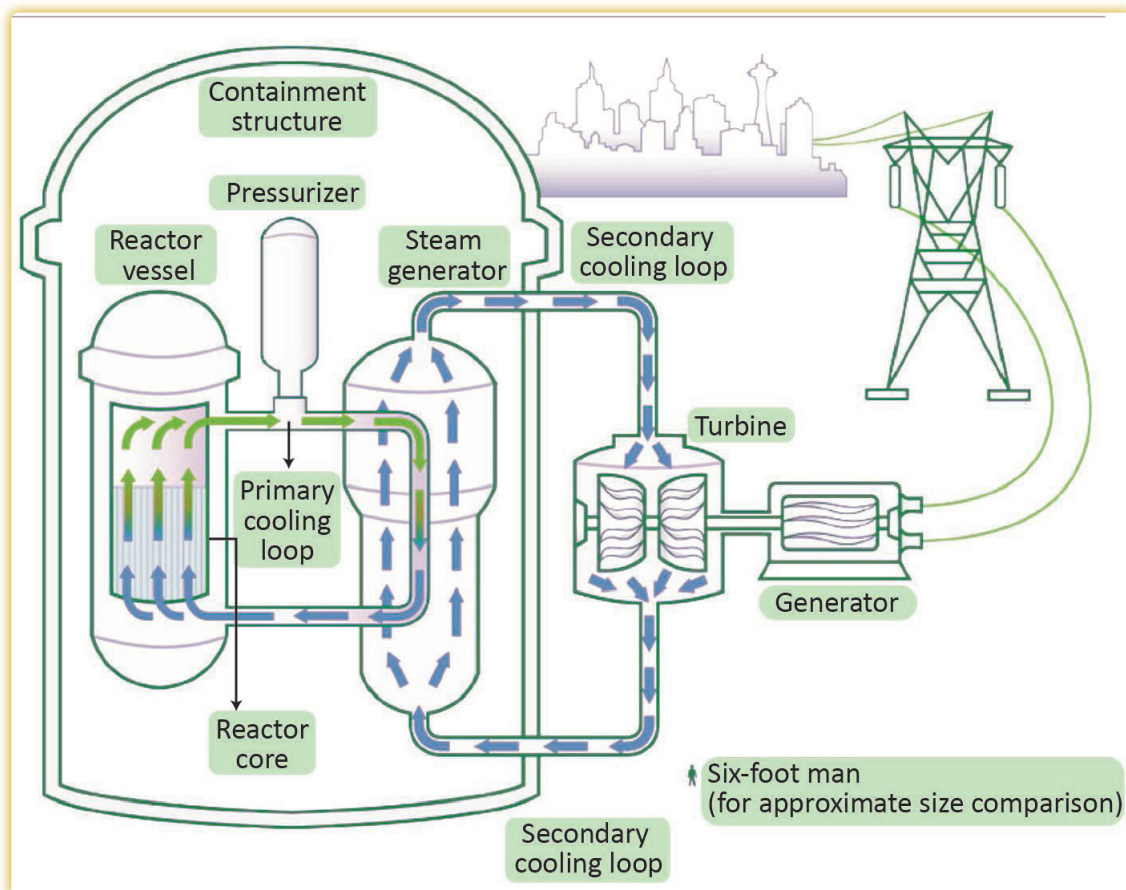
- The objective of IAEA Safeguards is to deter the spread of nuclear weapons by the early detection of the misuse of nuclear material or technology. Safeguards are an essential component of the international security system.
- The Treaty on the Non-Proliferation of Nuclear Weapons (NPT) is the centerpiece of global efforts to prevent the further spread of nuclear weapons. Under the Treaty's Article 3, each Non-Nuclear Weapons State is required to conclude a safeguards agreement with the IAEA.

NUCLEAR POWER PLANT

A nuclear reactor produces and controls the release of energy from splitting the atoms of certain elements.

Types of Reactors

Light Water Reactor



Light Water Reactor

The released energy is used as heat to make steam to generate electricity.

Main Components of a Nuclear Reactor:

- The Core-** It contains all the fuel and generates the heat required for energy production.
- Fuel-** Uranium is the basic fuel that is used for the production of nuclear power.
- Moderator-** It helps in slowing down the speed of neutrons which are released from fission reaction. Heavy water or Graphite can be used as moderators.
- Control Rods:** These are used to control the rate of reaction by using neutron-absorbing materials like cadmium or boron.
- Coolant:** It passes through the core and absorbs the heat and transfer it into the turbines.
- Turbines:** It transfers energy into the mechanical form.

What is Quantum Interference?

As qubits exist in superposition, they possess the inherent potential for quantum interference. Quantum interference refers to the probabilistic behaviour of qubits collapsing into specific states. However, in quantum computing, interference is both a blessing and a challenge.

On one hand, interference allows for complex computations and information processing by exploiting its constructive aspects. It enables the amplification of desired outcomes and facilitates the efficient execution of quantum algorithms.

On the other hand, interference can also lead to undesired outcomes and inaccuracies in the final results. To mitigate these issues, quantum computers employ techniques to minimize interference and enhance the reliability of computations.

How do Quantum Computers work?

Quantum computers operate on the principles of quantum mechanics to process and manipulate information. Here is a brief overview of how quantum computers work:

- **Qubits:** The basic unit of information in quantum computing is the qubit. Unlike classical bits that represent 0 or 1, qubits can exist in a superposition of states, representing both 0 and 1 simultaneously. This superposition allows quantum computers to perform computations in parallel, increasing their computational power exponentially.
- **Quantum Gates:** Quantum gates are analogous to the logic gates in classical computing. They are operations performed on qubits to manipulate their states. These gates include operations like the Hadamard gate, which creates superposition, and the Pauli gates, which perform rotations in the quantum state.
- **Entanglement:** Quantum entanglement allows for the creation of correlations between qubits. When qubits become entangled, their states become interdependent, regardless of their spatial separation. Manipulating one qubit in an entangled pair instantly affects the state of the other qubit, enabling powerful computational capabilities.
- **Quantum Algorithms:** Quantum computers utilize quantum algorithms designed to take advantage of the unique properties of qubits. These algorithms, such as Shor's algorithm for factoring large numbers or Grover's algorithm for database search, exploit superposition, entanglement, and interference to

perform computations more efficiently than classical counterparts in certain applications.

- **Quantum Measurement:** To obtain results from a quantum computation, qubits need to be measured. Measurement causes the collapse of the quantum state into a classical state, providing a specific outcome. The probability of obtaining a particular outcome is influenced by the quantum superposition and interference experienced by the qubits during the computation.

It's important to note that building and maintaining stable quantum systems is challenging due to factors like quantum noise and decoherence. Researchers and engineers work on developing error correction techniques and improving qubit stability to make quantum computers more reliable and scalable.

Application of Quantum Computing

Quantum computing has the potential to revolutionise various fields and solve complex problems that are computationally infeasible for classical computers. Here are some potential applications of quantum computing:

- **Cryptography:** Quantum computers could break many of the encryption algorithms used today, posing a threat to conventional cryptographic systems. However, quantum cryptography can also provide enhanced security through methods such as quantum key distribution.
- **Optimization:** Quantum computing can optimize complex systems and processes, such as logistics planning, resource allocation, and portfolio optimization. It can efficiently handle large-scale optimization problems and provide faster and more accurate solutions.
- **Drug Discovery:** Quantum computers can simulate and analyze molecular interactions, enabling more efficient drug discovery processes. They can help identify potential drug candidates, optimize drug properties, and simulate the behavior of complex biological systems.
- **Material Science:** Quantum simulations can aid in designing and discovering new materials with specific properties. Quantum computers can predict material behavior, simulate chemical reactions, and contribute to the development of advanced materials for various industries.
- **Machine Learning:** Quantum machine learning algorithms can enhance pattern recognition, optimization, and data analysis tasks. Quantum