



An Institute for Civil Services

MAINS TEST SERIES 2023

GS MAINS Q&A

REVISION TEST - 08
(10 QUESTION)

SCIENCE & TECHNOLOGY

Complete Syllabus

SCIENCE & TECHNOLOGY

REVISION TEST

Time Allowed: 90 Min.

Max. Marks: 125

Section - A

1. Highlighting the types of blockchain network, discuss how blockchain technology can be integrated into multiple areas.
2. "Geospatial technology will be crucial to drive the growth ambitions of the country". In this light, discuss the roadblocks in harnessing the full potential of India's geospatial sector and also comment on the recent policy efforts to de-regulate the sector.
3. Antimicrobial resistance (AMR) continues to pose a significant public health problem in terms of mortality and economic loss. Identifying the drivers of environmental Antimicrobial resistance (AMR) in India, highlight the steps taken by the government in this regard.
4. What are the advantages of thorium over other nuclear fuels? Explain the hurdles in the way of large-scale deployment of thorium-fuelled reactors in India.
5. What do you understand by the term 'Gravitational waves'? Bring out the significance of this discovery and explain why it is important for India to join the global network studying gravitational waves.

Section - B

6. Bringing out the key differences between 4G and 5G technology, discuss the potential benefits and challenges of 5G technology in India.
7. Graphene is considered as a 'wonder material' due to its inherent characteristics. Critically examine how it can help in the advancement of science and the economy of India.
8. Critically analyze whether GM Agriculture could be India's answer to agrarian crisis and malnutrition.
9. Innovation is the need of time to achieve the target of Atmanirbhar Bharat. Discuss. What are the steps taken by the Government to build a conducive environment for Innovation in India?
10. Discuss the advantages and application of remote sensing satellites. Also, highlight some of the remote sensing satellites launched by India and the various projects facilitated through them.



SCIENCE & TECHNOLOGY REVISION TEST

Section - A

1. *Highlighting the types of blockchain network, discuss how blockchain technology can be integrated into multiple areas.*

Approach

1. *The question requires analysis of Block chain technology in light of its types and uses*
2. *Contextually introduce with block chain technology*
3. *Highlight the types of blockchain networks*
4. *Then write about the various application of block chain technology*
5. *Conclude with the gist of your answer*

Hints:

A blockchain is a distributed ledger with growing lists of records (blocks) that are securely linked together via cryptographic hashes. Each block contains a cryptographic hash of the previous block, a timestamp, and transaction data. Blockchains are typically managed by a peer-to-peer (P2P) computer network for use as a public distributed ledger, where nodes collectively adhere to a consensus algorithm protocol to add and validate new transaction blocks.

Types of blockchain networks

- **Public blockchains:** A public blockchain has absolutely no access restrictions. Anyone with an Internet connection can send transactions to it as well as become a validator i.e., participate in the execution of a consensus protocol.
- **Private blockchains:** A private blockchain is permissioned. One cannot join it unless invited by the network administrators. Participant and validator access is restricted. To distinguish between open blockchains and other peer-to-peer decentralized database applications that are not open ad-hoc compute clusters, the terminology Distributed Ledger (DLT) is normally used for private blockchains.
- **Hybrid blockchains:** A hybrid blockchain has a combination of centralized and decentralized features. The exact workings of the chain can vary based on which portions of centralization and decentralization are used.
- **Sidechains:** A sidechain is a designation for a blockchain ledger that runs in parallel to a primary blockchain. Entries from the primary blockchain (where said entries typically represent digital assets) can be linked to and from the sidechain; this allows the sidechain to otherwise operate independently of the primary blockchain (e.g., by using an alternate means of record keeping, alternate consensus algorithm, etc.)

Application of block chain technology in multiple areas

- **Cryptocurrency:** Digital currencies are the new wave of assets that rely on blockchain. Though digital currency is already in use, blockchain companies are lowering the barrier of entry and providing a seamless exchange of the most popular crypto currencies as a banking alternative.
- **Smart contracts:** Blockchain-based smart contracts are proposed contracts that can be partially or fully executed or enforced without human interaction. A key feature of smart contracts is that they do not need a trusted third party (such as a trustee) to act as an intermediary between contracting entities – the blockchain network executes the contract on its own.
- **Financial inclusion:** Blockchain's low costs give startups a chance to compete with major banks, promoting financial inclusion. Blockchain can provide an alternative that uses digital identification and mobile devices, free from the hassle of traditional banking.
- **Money transfers:** Transferring money to other countries presents many problems and challenges for consumers and financial institutions. Blockchain can change all that.
- **Reduced fraud:** Blockchain stores information in a ledger with transaction information within each block, along with a unique hash that refers to the previous block. Every person within the network receives a copy of the transactions as well. Because of these features, blockchain technology is resistant to distributed denial-of-service attacks, hackers, and other types of fraud.

Block chain integrated into multiple areas in India

India has adopted and is planning to adopt the blockchain technology across various sectors.

- The '**National Strategy on Blockchain**' as brought out by the Ministry of Electronics and Information Technology (MeitY), Government of India, is the move in the direction towards enabling trusted digital platforms creating blockchain framework for the development of applications based on this technology.
- '**IndiaChain**': NitiAayog's ambitious project to develop a nation-wide blockchain network
- Several State governments including Andhra Pradesh, Telangana, Gujarat, Karnataka and Maharashtra, are using the technology for their e-governance initiatives.
- **The Telecom Sector:** The Telecom Regulatory Authority of India (TRAI) has instructed all telecom companies to start incorporating blockchain technology.
- **The Tea Board of India:** The Tea Board of India is planning to adopt blockchain technology to help increase traceability across the entire supply chain.
- **Securities and Exchange Board of India (SEBI):** SEBI has instructed all depositories to make use of blockchain technology to maintain records.

Conclusion:

Blockchain technology is among the emerging critical technologies that will fuel the 4th IR. Also, it holds potential to address long pending issues of healthcare, education, corruption. Thus regulating the use of Blockchain technology through a dedicated policy is imperative to reap its benefits.

2. ***“Geospatial technology will be crucial to drive the growth ambitions of the country”. In this light, discuss the roadblocks in harnessing the full potential of India's geospatial sector and also comment on the recent policy efforts to de-regulate the sector.***

Approach

1. ***In intro define Geospatial technology.***
2. ***Explain how Geospatial technology will be crucial to drive growth ambitions of the country and roadblocks affecting the sector.***

3. **Elaborate on potential of Geospatial technology (ex- Agriculture)**
4. **Discuss roadblocks faced by the sector and also discuss recent de-regulation of sector.**
5. **Conclude, by suggesting way forward.**

Hints:

Geospatial technology is an emerging field of study that includes Geographic Information System, Remote Sensing and Global Positioning System. It enables to acquire data that is referenced to the earth and use it for analysis, modeling, simulations and visualization. India's geospatial economy is currently valued at Rs 38,972 crore and has potential to grow to Rs 63,100 crore at 12.8 per cent by 2025 end.

How Geospatial technology will be crucial to drive growth ambitions of the country?

- **Agriculture:** Geospatial technology can be used in precision agriculture, monitoring of crop conditions etc.
- **Land use management:** Ex- Odisha has used high resolution maps produced by drone imagery to grant land title to its slum dwellers which decreased its slum population.
- **Employment:** Private Companies like Amazon, Zomato etc. use this technology to smoothly conduct their delivery operations which supports livelihood generation.
- **Implementation of Schemes:** The schemes like the Gati Shakti program can be smoothly implemented using geospatial technology.
- **Disaster risk reduction:** Ex- Cyclone Fani's impact was contained due to early warning systems, detection, etc. using Geospatial information.
- **Remote sensing satellites:** Ex- Oceansat series is being utilised for identification of potential fishing zones.

Some of the GIS based initiatives implemented in India are:

- India-WRIS (Water Resources Information System) developed by the ISRO to provide a single portal for all water resources data and information.
- National Spatial Data Infrastructure of the Department of Science and Technology

Roadblocks in harnessing full potential of India's geospatial sector

- Despite the existence of the National Data Sharing and Accessibility Policy 2012, there is no single platform that can be used by all departments to collate value-added data.
- There are challenges with respect to Super computers and quantum computers since they play a vital role in storage and processing of data. Ex- India's fastest supercomputer PARAM-Siddhi AI ranks 63rd
- Among the most prominent hurdles is the absence of a sizable geospatial market in India. There is no demand for geospatial services and products on a scale linked to India's potential and size.
- The other hurdle has been the lack of skilled manpower across the entire pyramid.
- Lack of data privacy law is also big challenge.
- National Spatial Data Infrastructure (NSDI) is only partially open and free for the public. Thus availability of innovation-fostering data to the private sector is limited.

Recent policy efforts to de-regulate the sector

The Centre is currently in the process of finalizing the draft National Geospatial Policy (NGP) and the Indian Satellite Navigation Policy (SATNAV Policy). It has already implemented Guidelines for Geospatial Data (Guidelines for acquiring and producing geospatial data and geospatial data services, including

maps) in 2021 which deregulated the previous protocol and liberalised the sector to a more competitive field. This is regarded as a watershed moment because:

- The policy granted open access to the geospatial data and services, including maps, for all Indian entities, with the exception of sensitive defence or security-related data.
- Indian corporations and innovators are no longer subjected to restrictions and do not require prior approvals before generating or updating digital geospatial data and maps within the territory of India.
- There is also no requirement for security clearance, licence or any other restrictions.

Conclusion:

United Nation Economic and Social Commission for Asia and the Pacific (UNESCAP) in its report titled “Geospatial Practices for Sustainable Development” praised India on India’s initiatives like BHUVAN, Water Resource Information System etc. Some steps need to be taken are-re-skilling of young workers, integrating geospatial data with other data sets, enhancing data security and privacy etc. International collaboration should also be leveraged to address the geospatial digital divide and other related issues. Although post de-regulation, the geospatial sector in the country is rightly positioned for investment but, it does need to create an enabling ecosystem for the utilization of its maximum potential.

3. Antimicrobial resistance (AMR) continues to pose a significant public health problem in terms of mortality and economic loss. Identifying the drivers of environmental Antimicrobial resistance (AMR) in India, highlight the steps taken by the government in this regard.

Approach

1. ***Contextually introduce with the Antimicrobial resistance (AMR) and briefly mention position of India in AMR***
2. ***Explain the drivers of environmental Antimicrobial resistance (AMR) in India. Here mention causing factor such as animal, biocides, Municipal waste water, Livestock discarded.***
3. ***Then write the initiatives taken by the government***
4. ***Conclude with the way forward***

Hints:

Antimicrobial Resistance (AMR) occurs when bacteria, viruses, fungi and parasites change over time and no longer respond to medicines making infections harder to treat and increasing the risk of disease spread, severe illness and death. As a result of drug resistance, antibiotics and other antimicrobial medicines become ineffective and infections become increasingly difficult or impossible to treat. AMR represents a major global threat across human, animal, plant, and environmental sectors. As per fifth detailed report on AMR trends and patterns from the country published by the ICMR, there has been sustained rise in antimicrobial resistance in India.

Drivers of environmental Antimicrobial resistance (AMR) in India

- **AMR contributed by antimicrobial use in animals:** India is an important producer of food animals for the global market in the form of meat, meat products and farmed seafood and a rise by 312 per cent in this market is expected by 2030.
- **AMR contributed by biocides:** Biocide is an umbrella term encompassing agents directed to kill the offending pathogen or microbe. It includes insecticides, pesticides, fertilizers and disinfectants.
- **Contaminated water as a source of AMR Pharmaceutical waste water:** India is one of the leading producers of pharmaceuticals in the world. Antimicrobial classes such as fluoroquinolones and sulphonamides produce stable residues while beta-lactam group of drugs degrade relatively faster

from the environment. While the former constitute an ever-growing pool of AMR, the latter indicates recent contamination of wastewater

- **Municipal waste water:** With 30-90 per cent fraction of all antimicrobials being excreted unchanged via human faeces and urine, municipal waste water becomes an important dumping ground of resistant organisms or genes. It is estimated that only 20-30 per cent of municipal waste water is treated in treatment plants and that too is not effective enough to eliminate the resistant organisms.
- **Hospital effluent:** Hospitals and all other healthcare facilities are important sources of generation of antimicrobial waste indirectly via patient secretions or directly as unused discarded medicines.
- **Livestock discard:** Animal excreta can contaminate the environment directly with resistant organisms or indirectly with antimicrobials.
- **Agricultural manure and sludge:** While manure is the natural or synthetic growth-promoter for crops, sludge is the undissolved slurry that is generated from biological treatment of waste water and is rich in micro-organisms and un-degraded pharmaceuticals.
- **Heavy metals:** Metals can have similar mechanisms of resistance, structurally or functionally, as that of antimicrobials like decreased membrane permeability, efflux pumps, target alterations, intracellular sequestration and the presence on the same plasmid.
- **Aquaculture:** With aquaculture becoming a fast growing industry in India and neighbouring countries, the injudicious use of antimicrobial agents to increase the productivity of farmed seafood can serve as an emerging source of environmental AMR.

Steps taken by the government

- India's National Action Plan (NAP) for AMR was released in April 2017 by the Union Ministry of Health and Family Welfare. The objectives of the NAP include improving awareness, enhancing surveillance measures, strengthening infection prevention and control, research and development, promoting investments, and collaborative activities to control AMR. On the basis of the NAP, various states have begun the process of initiating their State Action Plans.
- ICMR has initiated antibiotic stewardship program (AMSP) on a pilot project basis in 20 tertiary care hospitals across India to control misuse and overuse of antibiotics in hospital wards and ICUs.
- Drugs Controller General of India (DCGI) has banned 40 fixed dose combinations (FDCs) which were found inappropriate.
- ICMR worked in collaboration with Indian Council of Agriculture Research, Department of Animal Husbandry, Dairy and Fisheries and the DCGI to ban use of Colistin as growth promoter in animal feed in poultry.
- Various IEC activities like public conclave, poster and quiz competitions have been conducted by National Centre for Disease Control (NCDC) in schools, colleges and Health melas to create awareness about AMR, its containment & prevention and judicious use of antibiotics among the common public.
- To raise awareness among the community and the health care providers, communication material includes posters, videos and radio jingles has been developed with emphasis on prevention of irrational use of antibiotics during viral-illnesses and also on infection prevention through hand hygiene to prevent spread of infections.
- **Swachh Bharat Abhiyan:** The National Health Mission of India started the Swachh Bharat Abhiyan to improve the basic hygiene and sanitation in all spheres of life. As a part of this massive programme, education was imparted through mass media on the health hazards of open defecation.

Conclusion:

AMR in the environment has been a neglected topic in India so far. As per ICMR data analysis, between January 1 and December 31, 2021, there was a sustained increase in drug-resistant pathogens, resulting in difficulty to treat certain infections with available medicines. With environment in India posing a continuously increasing threat of AMR, urgent steps are necessary to halt its progress and spread. A multisectoral and multidisciplinary approach with combined efforts and supervision is required to tackle this problem.

4. *What are the advantages of thorium over other nuclear fuels? Explain the hurdles in the way of large-scale deployment of thorium-fuelled reactors in India.*

Approach

1. Give a brief overview on India's thorium reserves and state why India has not exploited its thorium reserves.
2. Bring out advantages of Thorium over other nuclear fuels. State the hurdles in India's nuclear energy capability.
3. Conclude with a relevant statement.

Hints:

Thorium is estimated to be available abundantly in the earth's crust. India's thorium deposits, which occur as placer deposits, are estimated to be 3, 60,000 tonnes (25-30% of known global reserves) while its Uranium deposits amount to only 1-2% of global reserves. Thorium is not fissile and has to be converted to Uranium-233 in a reactor before it can be used as fuel. Hence, a three-stage nuclear power programme, based on a closed nuclear fuel cycle has been chalked out to use thorium as a viable and sustainable option. The first two stages focus on natural uranium (U-238)-fuelled heavy water reactors and plutonium- fuelled fast breeder reactors respectively and are intended to generate sufficient fissile material from India's limited uranium resources. This will allow India to use its vast thorium reserves in the third stage of thermal breeder reactors.

Advantages of thorium over other nuclear fuels can be enumerated as:

- Thorium cycles exclusively allow thermal breeder reactors as opposed to fast breeders which don't use moderators. More neutrons are released per neutron absorbed in the fuel in a traditional (thermal) type of reactor. This means that if the fuel is reprocessed, reactors could be fuelled without mining any additional U-235 for reactivity boosts, which means the nuclear fuel resources on Earth can be extended by 2 orders of magnitude.
- Thorium reactors produce far less waste than present-day reactors.
- The Th-U fuel cycle does not irradiate Uranium-238 and therefore does not produce transuranic(bigger than uranium) atoms like Plutonium, Americium, Curium, etc. These transuranic are the major health concern of long-term nuclear waste.
- Thorium is more abundant in Earth's crust than Uranium and Thorium reactors are cheaper because they have higher burn up.
- Thorium is generally accepted as proliferation resistant compared to Uranium-Plutonium cycles.

The hurdles in the way of large-scale deployment of thorium-fuelled reactors in India are as follows:

- The single greatest hurdle is the critical shortage of fissile material. A fissile material is one that can sustain a chain reaction upon bombardment by neutrons. Thorium is by itself fertile, meaning that it can transmute into a fissile radioisotope but cannot itself keep a chain reaction going.
- Also, it would take India many more Fast Breeder Reactors and at least another four decades before it has built up a sufficient fissile material inventory to launch the third stage.

- It is the shortage of uranium fuel (U-235) that is needed to convert thorium into fissile U-233 that can undergo sustained chain reaction. The Indo-US Nuclear deal is expected to boost nuclear trade which will help India's nuclear programme.
- Delay in commissioning of the Prototype Fast Breeder Reactor (PFBR) presently being constructed at the Madras Atomic Power Station in Kalpakkam. The success of the 3 stage programme will require several Breeder Reactors. Large scale thorium deployment is only to be expected 3 - 4 decades after the commercial operation of fast breeder reactors

Conclusion:

The use of thorium as a new primary energy source has been a tantalizing prospect for many years. Extracting its latent energy value in a cost-effective manner remains a challenge for India, and will require considerable R&D investment.

5. *What do you understand by the term 'Gravitational waves'? Bring out the significance of this discovery and explain why it is important for India to join the global network studying gravitational waves.*

Approach

1. *The question requires the analysis of Gravitational waves*
2. *The demand of the question is to discuss the importance of their discovery and India's LIGO project*
3. *In the intro, define Gravitational waves*
4. *Then elaborate on the importance of their discovery and explain India's LIGO project*
5. *Conclude, by suggesting a way forward*

Hints:

Gravitational waves are ripples in space-time traveling at the speed of light caused by some of the most violent and energetic processes in the Universe. They carry with them information about their cataclysmic origins, as well as invaluable clues to the nature of gravity itself.

Different types of gravitational waves are- Continuous gravitational waves, Compact binary inspiral gravitational waves, and Stochastic Gravitational Waves. Gravitational Waves are invisible ripples in space that form when:

- A star explodes in a supernova
- Two big stars orbit each other
- Two black holes merge
- Neutron star-Black hole (NS-BH) merges

Albert Einstein predicted the existence of gravitational waves in 1916 in his general theory of relativity. GWs were first detected in 2015 by LIGO (The Laser Interferometer Gravitational-Wave Observatory), located in the US.

Significance of the detection of Gravitational Waves by LIGO

- Gravitational waves will give more information about black holes and neutron stars that exist in the Universe
- They will also give us insight into what happens during some of the Universe's most violent explosions
- Gravitational waves will provide a test of Einstein's theory of general relativity under extreme conditions of gravity where it has never before been tested.
- They will give information about the dense form of matter that makes up neutron stars

Initiatives taken by India in studying gravitational waves

India's LIGO project

- LIGO was designed for the direct detection of gravitational waves. LIGO uses laser interferometry to measure the minute ripples in space-time caused by passing gravitational waves from cataclysmic cosmic events such as colliding neutron stars or black holes, or supernovae.
- It is being operated at two sites in the US (Washington and Louisiana). Also, there are LIGO's sisters' facilities in Italy, Germany, and Japan
- In 2016, the central government had given approval to LIGO-India (a Joint India-US detector) for research on gravitational waves.

LIGO-India observatory

- LIGO-India is a planned Gravitational-Wave Observatory that will be located in India as part of the worldwide network.
- The LIGO-India observatory will be built in the Hingoli District of Maharashtra.
- The project involves constructing a network of L-shaped arms, each four kilometers long, which can detect even the faintest ripples from cosmic explosions millions of light-years away.
- The project piloted by the Department of Atomic Energy and Department of Science and Technology and is expected to be ready by 2025.

Significance of LIGO- India

- Will raise the appeal of experimental science in India and will be helpful to inspire students to pursue technical careers.
- There will be spinoff cutting-edge technologies that have many non-military applications.
- Establishing an observatory in India also assumes importance because the further the distance between the observatories, the greater will be the accuracy in locating gravity waves.
- It will help the Indian scientific community to be a major player in the emerging research frontier of Gravitational Wave astronomy

Conclusion:

LIGO-India observatory is a watershed moment not just for gravitational wave science but also for India. The project will bring unprecedented opportunities for Indian scientists and engineers to dig deeper into the realm of gravitational waves and take global leadership in this new astronomical frontier.

Section - B

6. *Bringing out the key differences between 4G and 5G technology, discuss the potential benefits and challenges of 5G technology in India.*

Approach

1. *The demand of the question is discuss the benefits of 5G and challenges in adopting it*
2. *In intro define 5G*
3. *Then elaborate on differences between 4G and 5G and*
4. *Write about the potential benefits of 5G technology then discuss challenges in adopting 5G (Ex-high investment, fibre requirements, unavailability of some bands, etc)*
5. *Conclude, by suggesting way forward*

Hints:

India has been seeing rapid growth in the Telecom Industry. The evolution of various generation of the network has impacted the economy and society positively. The current era has witnessed the wide usage of the 4th generation network. The 5G is the next generation wireless cellular technology that will provide faster and more reliable communication with ultra-low latency. A government panel report points out that with 5G, the peak network data speeds are expected to be in the range of 2-20 Gigabit per second (Gbps).

The key differences between the 4G and 5G network are listed below:

- 5G network provides enhanced network coverage compared to the 4G.
- Data bandwidth of 5g is above 1gbps whereas for 4G it lies between 2mbps to 1gbps.
- The latency of the 5G network is smaller (Less than 10 millisecond) compared to 4G (20-30millisecond)
- 5G network operates at higher frequency band to allow faster data transmission compared to the 4G network.

Potential benefits of 5G technology are

- 5G density enables up to 100 times more connected devices in the same physical area that 4G LTE operates today, while maintaining 99.99% availability. While this density may bring business advantages for mobile workforces, the real benefit is increasing the size of the mobile customer market.
- An estimated 90% reduction in power consumption for devices means minor power savings at the smartphone level. But, from an infrastructure perspective, especially for IoT devices, the power savings could be significant
- With 5G, stronger security than 4G LTE is available for designers, including hardware security modules, key management services, over the air, secure element and others. This will help ensure that the data transmitted over the 5G network is secure while also hardening network endpoints.
- **Entertainment and multimedia:** 5G can provide 120 frames per second, high resolution and higher dynamic range video streaming without interruption. Audiovisual experience will be rewritten after the implementation of the latest technologies powered by 5G wireless. Augmented Reality and virtual Reality services will be better experienced over 5G.
- **Smart cities:** Smart city application like traffic management, Instant weather update, local area broadcasting, energy management, smart power grid, smart lighting of street, water resource management, crowd management, emergency response etc can use a reliable 5G wireless network for its functioning.
- **Employment generation:** 5G wireless technology will open greater opportunity for new device manufactures and application developers. New VoIP devices and smart devices will be introduced in the market and thus more job opportunities as well. This will help in inclusive growth reaping demographic dividend.

Challenges involved in 5G adoption

- It requires huge investment for research, manpower and capacity development by private players to make it a profitable venture.
- 5G needs a significant amount of new harmonized mobile spectrum to deliver wide spread coverage. This may be difficult due to unavailability of some bands
- Imports account for about 90% of India's telecom equipment market resulting in high import dependency on the complete 5G supply chain. GOI has also excluded firms like Huawei and ZTE from the 5G roll out in India which further complicates the matter.

- It will add to the spectrum cost. Currently, AGR dues have taken a huge toll on Telecom operators in India like Vodafone, Airtel.
- It will require large scale optical fibre connectivity. Currently, such connectivity is limited to metropolitan cities of India while hinterlands surrounding them remain aloof of even good 4G connectivity.
- With a growing digital economy, the threat of cyber-attacks will loom large.

Conclusion:

India should not miss the opportunity and should proactively work to deploy 5G technology. 5G start-ups that enable this design and manufacturing capabilities should be promoted. This will spur leaps in the coverage, capacity and density of wireless networks. Earlier adoption of 5G will help India encash on current programmes like Digital India. 5G will help India towards becoming a frontrunner in 4th Industrial Revolution driven by enhanced digital connectivity.

7. *Graphene is considered as a 'wonder material' due to its inherent characteristics. Critically examine how it can help in the advancement of science and the economy of India.*

Approach

1. The question requires analysis of graphene on the basis of its application, initiatives taken in India and challenges
2. Briefly introduce by defining graphene and potential of graphene development in India
3. Discuss various applications and usage of Graphene
4. Then highlight the Steps taken in India and challenges along with suggestions
5. Conclude with the way forward

Hints:

Graphene is a one-atom-thick layer of carbon atoms arranged in a hexagonal lattice. It is the building-block of Graphite. It is the thinnest, most electrically and thermally conductive material in the world, while also being flexible, transparent and incredibly strong. Graphene has good chemical stability as well as large surface area but lightweight. India's Graphene market is growing at a high rate because of the driving factors such as increasing demand for graphene in the electronics and automobile industry and growing investment towards the development of renewable energy sources.

Applications and usage of Graphene

- Often referred to as a wonder material for its extraordinary electrical and electronics properties, it could **replace Indium** and which will bring down the **cost** of OLED (organic light-emitting diode) screens in smartphones, TVs and other appliances.
- It is helpful in making **anti-corrosion coatings and paint** which will increase the durability and decrease maintenance cost.
- It **enhances the sensors** in electronic devices, making them efficient and more responsive.
- It can make displays screens more **flexible** thereby unleashing whole new venture in electronics design and product manufacturing.
- It makes **solar panels** more effective thereby decreasing import cost.
- In biomedical sector: It will enhance DNA sequencing, **drug delivery, and other biotechnologies** for improving human health and lower disease burden
- In 2020, graphen**masks** that inactivate the coronavirus were made.

- In defence sector: It will provide more strength to domestically manufactured defence equipments and vehicles.
- Graphene supercapacitors act as energy storage devices with a potential for **faster charging and longer life span** than traditional electrolytic batteries.

Steps taken

- Recently, the Kerala government announced to set up **country's first Graphene Innovation Centre at Thrissur, Kerala**. It will be established jointly by Digital University of Kerala, Centre for Materials for Electronics Technology (C-MET) and Tata Steel Limited.
- The Graphene Innovation Centre will be a cross-disciplinary innovation centre that will promote **ecosystem** for developing new ideas and applications.
- It will create **opportunities** across state and whole of India for companies and individual too and **collaborate** with leading agencies all around the world.
- It will foster a culture of innovation through the **creation, sharing, and testing of ideas** with adequate **facilities and infrastructure**. The state government would provide the basic infrastructure for the project. The Centre would help attract investors to develop graphene products.
- The project would prove to be a boon for **scientific research** along with development of nation's **industrial sector**.
- **In July 2021**, Tirupati Graphite, UK-based graphite, and graphene company started its revenue generation at the Tirupati Graphene and Mintech Research Center (TGMRC) in India and is advancing its commercializing engagements.
- **In July 2021**, Nanomatrix Materials, an Indian smart material manufacturer, announced to be working on large-scale manufacturing to develop antiviral face masks, AC filters, HVAC filters, and more using the proprietary graphene technology

Challenges

- Graphene development and graphene based technologies are at **nascent stage** in India.
- There is a dearth of **skilled manpower** as only 2% of labour force is certified as skilled from recognized institutions as compared to South Korea where it is 96%.
- Lack of **investment attraction opportunities** due to infrastructural gaps
- The **logistics sector** is marred by high cost of upto 14% of GDP as compared to 6-8% in developed nations
- Low **financial outlay** for research in graphene based product and design.
- **High import cost** due to high demand but low manufacturing base.
- Creation of high quality graphene is **expensive and complex** process.
- As a catalyst, it has high susceptibility to **oxidative** environments.
- To develop graphene, toxic chemicals are being used at high temperatures. Hence, it possesses some **toxic components**.

Following can be done to address the above problems:

- Creating of **Plug and Play model** for promoting start-up culture in graphene based technologies as we have in Pharmaceutical sector.
- Increase **budgetary** outlays for emerging technologies including graphene.
- Bring up new **certification courses** in field of Graphene Designs and Prototypes.

- Creating a **dedicated cluster** to address infrastructural inadequacies.
- Government should enter into **Bilateral and Multilateral agreements for technology transfer** with nations like US, UK, Germany etc.
- **Private sector** should engage with world leading companies to boost production of graphene based appliances.
- **Academia - Industry collaboration** should be promoted and institutions like IITs, NIITs shall have a dedicated cell for research in graphene.
- A dedicated **Graphene Development Policy** should be brought forth by respective state governments for decentralised development of the sector.

Conclusion:

Graphene is the new gold of electronics market around the globe. Its features and advantages hold immense potential to transform our economy in various sectors like biomedical, defence, electronics, energy, and sensors. So the Central as well as state governments need to give thrust to the development of this sector to reap the benefits from merging 2D and 3D materials market having a wide range of commercial and industrial applications.

8. *Critically analyze whether GM Agriculture could be India's answer to agrarian crisis and malnutrition.*

Approach

1. *Describe GM Agriculture*
2. *GM Agriculture as a solution to Agrarian Crisis and Malnutrition*
3. *Concerns of GM Crops*
4. *Way Forward and Conclusion*

Hints:

In order to meet our ever increasing demand for foodgrains and keeping in mind the limited land and water resources, high input cost, worsening soil health, dependence on rain, increasing indebtedness, stagnated productivity, and climatic changes, innovative scientific and technological efforts are the need of the hour to give fillip to our agricultural production so as to ensure food security of the country on a sustainable basis. Thus the genetically modified crops (GM crops) have been developed for a variety of purposes and reasons such as enhancing agricultural productivity, reducing dependence on the use of pesticides, improving the agronomic performance of crop plants; enhancing the nutritional value of foods and feeds etc.

GM agriculture is believed to be India's answer to agrarian crisis and malnutrition

- **Food Security:** By 2050, the world's population is expected to expand from 7 billion to 9 billion. Accordingly, the global food production will have to double over the next 32 years. Yet the amount of farm land is shrinking. Biotechnology is the only way to feed that growing population, by increasing yields to get more food from less land. It has helped farmers grow 311.8 million tonnes more food in the last 15 years. GMOs mean cheaper, more plentiful food to fight hunger in a country like India.
- **Resistance to pests and protecting the environment:** Through genetic modification, scientists can give crops built-in resistance to pests. That means less need for pesticides that are potentially harmful to the environment. By reducing the need to spray, GMOs also cut farmers' fuel emissions, helping to fight global warming. They can be engineered to withstand weather fluctuations and extremes.
- **Improved taste and longer shelf life:** Foods can be genetically modified to improve flavour and texture. Genetic modification can also give food a longer shelf-life - meaning consumers get fresher taste and the environment benefits from less waste.

- **Improvement in health and nutritional values of food:** Biotech can make food healthier, giving lettuce a greater concentration of nutrients, reducing starch in potatoes or lowering the saturated-fat content of cooking oils. Studies suggest genes introduced into GMO tomatoes can increase their natural production of antioxidants that might help prevent cancer or heart disease.
- **Reducing dependence on imports:** Just as the adoption of Bt cotton ensured that India transitioned into a cotton-exporting country, switching to high-yield oilseeds engineered specially for India's semi-arid zones can help India reduce its dependence on imports. At \$10 billion annually, edible oil is India's third-biggest import item after crude oil and gold.
- **Higher income for farmers:** GM crops cut costs for consumers and raise livelihoods for farmers.

However, there have been several concerns and risks regarding GM crops

- **Risk to the environment:** GMOs are a serious risk to the environment. Their seeds travel well beyond fields where they are grown. Cross-pollination creates herbicide-resistant "super weeds" that threaten other crops and wild plants. Tampering with crops' genetic make-up impacts down the food chain.
- **GMOs might pose an array of health concerns:** GMOs increase resistance to antibiotics, making medicines less effective. Fears have been raised over possible links to cancer, reproductive malfunction, digestive disorders etc. GM crops can cause long term consequences on human health.
- **Monopoly of companies that own the patents on GMO seeds:** Farmers remain at the mercy of companies that own the patents on seeds and set the prices. So-called "terminator technologies" could prevent growers using last year's seeds to plant new crops, forcing them to keep buying from the GMO companies. It makes the farmers susceptible to the practices of these MNCs and can raise the cost of cultivation and put them in debt trap.
- **Effect on Environment:** There are plenty of evidence to counter claims that GMO will increase world food yields and show non-GMO crops can perform even better. GMO production favours big business over small farmers and encourages the trend toward industrial-scale "monoculture" growing that's bad for the environment, farmers and consumers. GMOs are self-replicating organisms and causes genetic contamination of the environment which cannot be reversed.
- **Crop loss due to resistance developed by pests:** GM technology has been known to cause crop loss due to resistance developed by pests and destruction of local crop varieties, impacting biodiversity.

India's experience with GM crops

- Currently, India has the world's fourth largest GM crop acreage on the strength of Bt cotton, the only genetically modified crop allowed in the country. The introduction of Bt cotton has been both highly successful and controversial.
- However, the recent reports suggest that, Bt cotton is not a complete failure in India. The yields hovering around 300 kg/ha at the time of introduction of Bt cotton (2002) have increased to an average of over 500 kg/ha, converting India from a cotton-importing country to the largest exporter of raw cotton, according to the Economic Survey 2011-12. But it was also shadowed by controversy, with a tangle of pricing and intellectual property rights (IPR) issues followed by government price interventions and litigation.
- The moratorium on Btbrinjal is the most unfortunate step taken by the government in 2010 and has crippled the entire field of research and development with transgenic crops. Bangladesh has used India's data to successfully cultivate Btbrinjal, despite all the negative propaganda. Reports indicate that as many as 6,000 Bangladeshi farmers cultivated Btbrinjal in 2017.

Conclusion:

The government should adopt a participatory approach to bring together all stakeholders to develop regulatory protocols that restore trust in the process. Agriculture is a state subject therefore, it is

important for the centre government to take into consideration the views of State Governments as well. However, it is also true that dependence on GM crops is a risky proposition. Hence, India needs to tap the potential of other technologies. As pointed out by a parliamentary committee, India has better options for increasing productivity, like molecular breeding and integrated pest management that can serve it in good stead for the time being.

9. *Innovation is the need of time to achieve the target of Atmanirbhar Bharat. Discuss. What are the steps taken by the Government to build a conducive environment for Innovation in India?*

Approach

1. *Introduce by giving a definition of Innovation*
2. *Enumerate how innovation can help India in achieving targets of Atmanirbhar Bharat*
3. *Enumerate the steps taken by the Government in building a conducive environment for Innovation*
4. *In conclusion write the way forward*

Hints:

Innovation is the practical implementation of ideas that result in the introduction of new goods or services or improvement in offering goods or services.

Innovation and Atmanirbhar Bharat:

- Innovation is seen as an important factor that contributes to the long-term development of an economy. The history of civilisations has been a story of human beings learning newer, easier, and more efficient ways of carrying out mundane but necessary activities.
- India needs greater thrust on innovation to catapult itself to a higher growth trajectory and become the third largest economy in GHDP current US\$ in the near future. This requires boosting gross expenditure on R&D from 0.7 per cent of GDP currently, to at least the average level of Gross Domestic Expenditure on(GERD)in other top ten economies (GDP current US\$) of over two per cent. It also involves significantly calling up R&D personnel and researchers in the country, especially in the private sector.
- Atmanirbhar Bharat Abhiyaan or Self-reliant India campaign aims to make the country and its citizens independent and self-reliant in all senses.
- The outlined five pillars of AtmaNirbhar Bharat are – Economy, Infrastructure, System, Vibrant Demography and Demand.
- Innovation is one of the most important driving forces behind a successful economy.
- COVID can be seen as an example of how innovation can help India in becoming self-reliant.
- The development of Vaccines for Corona made India self-reliant in this entire pandemic.
- Emerging problems like Climate Change can be solved through innovative solutions.

Steps taken by the Government to build a conducive environment for Innovation:

- **NIDHI Program:** Department of Science & Technology has launched a NIDHI program (National Initiative for Developing and Harnessing Innovations) under which programmes for setting up of incubators, seed fund, accelerators and 'Proof of concept' grant for innovators and entrepreneurs have been launched.
 - Under NIDHI, PRAYAS (Promoting and Accelerating Young and Aspiring innovators & Startups) programme has been initiated in which established Technology Business Incubators (TBI) are supported with PRAYAS grant to support innovators and entrepreneurs with grants for 'Proof of Concept' and developing prototypes.

- **Atal Innovation Mission:** To boost entrepreneurial spirit in India, the Atal Innovation Mission (AIM), a flagship initiative of NITI Aayog, is supporting two programs for setting up and scaling up of incubation centres.
- **Technology Incubation and Development of Entrepreneurs (TIDE) Scheme** was put in place by MeitY in 2008 to promote innovation by nurturing startups in the Information Technology, Communications & Electronics (ICTE) domain.
- **Incentivising Research and Development:** Innovation needs risk capital in terms of resources and psychological security for researchers. The Government has launched various schemes like
 - Innovation in Science Pursuit for Inspired Research (INSPIRE) scholarships,
 - the Ramanujan Fellowship,
 - the Knowledge Involvement in Research Advancement through Nurturing (KIRAN) scheme,
 - Smart India Hackathons (SIH),
 - the Biotechnology Ignition Grant (BIG) scheme,
 - Scheme for Transformational and Advanced Research in Sciences (STARS),
 - Scheme for Promotion of Academic and Research Collaboration (SPARC) and
 - Impactful Policy Research in Social Science (IMPRESS).
- **Skill Development:** The Government has set up the Future Skills PRIME (Programme for Reskilling/ Upskilling of IT Manpower for Employability) capacity building platform.

Conclusion:

Innovation in India is being structured around the triad of collaboration, facilitation and responsible regulation. As focus shifted on innovation, several start-ups have disrupted Indian markets. India has improved its rank in WIPO's Global Innovation Index. Thus, a positive push by the Government has led to a paradigm shift in India's innovation ecosystem and this is just the beginning of a new era of innovative transformation of the country.

10. Discuss the advantages and application of remote sensing satellites. Also, highlight some of the remote sensing satellites launched by India and the various projects facilitated through them.

Approach

1. Briefly introduce remote sensing satellites
2. Advantages of the remote sensing satellites. Application of remote sensing satellites
3. India's remote sensing satellites. Various remote sensing satellite projects taken in India
4. Conclude with the gist of your answer

Hints:

Remote sensing is deriving information about an object from a distance without physically coming into contact with the object. It is based on the principle that different objects have different radiation characteristics. It is useful for monitoring and assessment of natural resources etc, through the analysis of data obtained by observation from remote platform. The characteristics of an object can be determined by using reflected or emitted electro-magnetic radiation from the object. Actually each object has a unique and different characteristics of reflection or emission. Thus, remote sensing is a technology to identify and understand the object through the reflection or emission.

Advantages of remote sensing satellites

- The advantages of the satellite based remote sensing are its wide coverage, saving in time and tremendous cost effectiveness over other techniques.
- Large area coverage enabling regional survey of variety of themes and identification of large features.
- Repetitive coverage, allowing monitoring of dynamic themes like water, agriculture, etc.
- Data acquisition at multiple heights
- Data acquisition over inaccessible areas

Applications of remote sensing satellite

- **Natural resource management:** The satellites can be used to chart wildlife habitats, map wetlands, and monitor land use. The acquired data can minimize damage caused by urban growth and help decide the best course of action to protect natural resources.
- **Hazard assessment:** Earth remote sensing satellites can keep track of flooding, erosion, earthquakes, and hurricanes. The data can help assess the impact of the natural disaster and even prep strategies before the hazardous event.
- **Ocean application:** One of the many remote sensing satellite uses is tracking sea ice, measuring wave heights and ocean temperature, and monitoring current systems and ocean circulation. This technology will help you understand the oceans better and create strategies to manage the ocean resources best.
- **Coastal applications:** With remote sensing satellites, you can map coastal features, track sediment transport, and monitor shoreline changes. Also, the remote sensing satellite data can be used for erosion prevention and coastal mapping.
- **Agriculture:** By using these satellites land-use pattern can be mapped, it also helped in determining soil moisture and can estimate crop production.
- Studying glacier melts and effects on sea levels.
- It can help in tracking of displaced refugees
- It helps in measuring albedo for Earth's radiation budget.

Indias remote sensing satellites

- **Resourcesat - 1:** For advanced applications like vegetation dynamics, crop yield estimates, disaster management support.
- **Cartosat - 1:** For the preparation of cartographic maps, cadastral mapping updation, land use and GIS applications.
- **Oceansat - 2:** To study surface winds, ocean surface strata, suspended sediments in the water.etc.
- **Risat - 2:** India's first satellite with SAR imager all weather capability to take images of the earth.
- **SARAL:** satellite with Argos and ALtika to develop operational oceanography & forecasting capabilities.

Various remote sensing satellite projects taken in India

- Several remote sensing application projects have been carried out in the country under the National Natural Resources Management (NNRMS) of the Department of Space in coordination with central and state departments.

- Various remote sensing projects taken up in India are:
 - National waste land mapping
 - Land cover mapping
 - Agriculture drought mission
 - Forest cover mapping
 - Flood mapping
 - Project vasundhara
 - Environmental impact assessment....etc.

Conclusion:

Scientists use infrared images to determine the conditions of vegetation, survey temperature changes in water bodies, locate damage in underground pipelines, and map certain geographic features above and below the ground. The images from the satellites are used in the search for mineral and petroleum deposits. So, the remote sensing technology and remote sensing satellites have multiple applications and help in the social, political, economic, environmental development of the country.

