



An Institute for Civil Services

MAINS TEST SERIES 2023

GS MAINS Q&A

TOPICAL TEST - 50
(5 QUESTION)

SCIENCE & TECHNOLOGY

Computer and IT, AI, robotics, Space, defence

SCIENCE & TECHNOLOGY - 2

Time Allowed: 50 Mins.

Max. Marks: 75

1. Robotics technology has potential to enhance our lives as it saves human efforts and energy. Elaborate. Also, explain the various robotics projects and challenges faced by India in optimum utilization of this technology.
2. Explaining India's first Manned Mission into Space, discuss how it will contribute to technological, economic and educational development of India.
3. Neutrinos play a key role in many fundamental aspects of our lives. Elaborate on the significance and potential applications of Neutrinos. Also, highlight India's initiative in neutrino research.
4. "Due to its precise data collection and accuracy, LIDAR is one of the most sought after technologies in the world today". Discuss the significance of LIDAR technology for industrial, commercial, and scientific applications.
5. The applications of Unmanned Aerial Vehicle (UAVs) are not limited to the military world; the usage has been expanding rapidly in many fields. Elaborate. Also, highlight some of the measures taken by the government of India to regulate the usage of drones.



SCIENCE & TECHNOLOGY - 2

1. *Robotics technology has potential to enhance our lives as it saves human efforts and energy. Elaborate. Also, explain the various robotics projects and challenges faced by India in optimum utilization of this technology.*

Approach

1. Briefly introduce robotic technology
2. Applications of robots
3. Robotics projects in India and challenges of robotics in India.
4. Conclude with the way forward

Hints:

Robotics is a branch of science and technology which deals with design and manufacturing of robots using computer applications. It is an interdisciplinary field merging together at least mechanical, electronics and computer science engineering.

Robot is a mechanical agent, usually an electro-mechanical machine that is guided by a computer program or electronic circuitry. Robots can be autonomous or semi-autonomous and range from humanoid to industrial robots, collectively programmed 'swarm' robots, and even microscopic nano robots.

Applications of robots:

There are various applications of robots in different fields for different purpose. They are:

- **Automobile industry:** Industrial robots are known for its speed, accuracy and reliability. They are used in assembling of parts, welding, spraying and material handling.
- **Electronics:** Robots used to fit chips in motherboard of a machine. These chips are very small in size and hence difficult for humans to fit it.
- **Military applications:** Tele robots used as UAVs to perform military operations at dangerous far away or inaccessible places.
- **Health & medicine:** Robotic surgery has been developed with the technological development and also nano-robots are used to take medicines to targeted organs helping in medical treatment of humans.
- **Environment:** Nano robots can be used to clear oil spills & disassemble pollutants specially non-biodegradable ones reducing pollution impact.
- **Disaster Management:** Robots can be used in nuclear plants for handling & disposal of nuclear waste material and also during the scenario of Nuclear disaster.
- **Other Fields:** It is also used in Exploration, Farms, Entertainment

Robotics projects in India: Several institutions and universities are involved in Robotics and related fields.

- **Indian Institute of Science (Bangalore)**, etc are having robotic laboratories.
- **BARC** uses robots in nuclear waste handling. So some of the robotic projects taken up by Indian government institutions are:
- **Centre for Artificial Intelligence & robotics (CAIR)**, Bangalore has developed a robot by the name 'CHATUR'. CHATUR robot is developed with vision sensor to pick up objects in the visual field.
- **DRDO** has initiated a project to make Robotics Soldiers Deployed in the LOC (Line of Control) but the challenge is to integrate cognitive skills under AI to differentiate between a threat and a friend.
- DRDO has developed a robot by the name 'DAKSH'. It is a counter terrorist remotely operated designed to handle hazardous material and suspect object in public places. It is provided with multiple cameras used for surveillance.

Challenges of robotics in India

- **Procurement of hardware components:** The cost of adopting Robotic technology is very high due to the cost of procuring imported hardware components as well as training personnel.
- **Skilled Manpower:** As Robotics is a multidisciplinary field, acquiring and retaining quality talent is a big issue. The capital-intensive nature of Robotics adoption when compared to the low cost of human labour clearly tips the scale in favour of the latter.
- **Educational Institutions:** As Robotics is multidisciplinary in nature, barring students in the top schools in India, the others lack the knowledge required in four to five engineering disciplines to become an expert in this field. Also most of the students develop projects that already exist in the public domain.
- **Scarcity of good faculty to teach the subject:** Barring a few regions in India, Robotics as a subject is not taught well to the engineering students.

Conclusion:

There are many concerns about the development and use of robotics in every sector, as they may replace humans in all manual and industrial works in the future. In manufacturing sector, already most of the industries are replacing humans with robots for better work efficiency and productivity. As there is an increase in the unemployment rate in the country, the government should take care to avoid job loss to the people of the country. But some argue that, even though robots may replace humans in many sectors, they may create more opportunities or create jobs in the associated sectors related to industries as there is increased work efficiency and productivity.

2. *Explaining India's first Manned Mission into Space, discuss how it will contribute to technological, economic and educational development of India.*

Approach

1. *Briefly introduce with India's first Manned Mission into Space*
2. *Discuss features of India's 1st manned space mission*
3. *Explain the multifarious advantages of launching our own Manned Mission for the 1st time.*
4. *Conclude with how this mission will place India in the club of Space Superpowers and will have multiplier effects on India's trajectory.*

Hints:

India's first indigenous Manned Space programme (Gaganyaan Mission) is set to launch Indian astronauts to space.

It intends to send 3 astronauts to space by 2022, as part of the Indian Human Spaceflight Programme. This will make India the 4th nation in the world to launch a Human Spaceflight Mission.

Features of India's 1st manned space mission:

- The Gaganyaan Programme will undertake the demonstration of human spaceflight to Low Earth Orbit (LEO) in the short term and will pave the way for future Indian human space exploration programmes in the long run.
- In its maiden crewed mission, ISRO's largely autonomous 5.3 t (12,000 lb) capsule will orbit the Earth at 400 km altitude for up to seven days with a three-person crew on board.
- The objective of the Gaganyaan programme is to demonstrate the indigenous capability to undertake human space flight missions to LEO.
- **The major new technologies involved in the Gaganyaan Mission are:**
 - Human rated launch vehicle
 - Crew escape systems
 - Habitable orbital module
 - Life support system
 - Crew selection and training and associated crew management activities
- **International Collaboration:** ISRO has collaborated with various international partners for training and logistics support like ROSCOSMOS (the Russian space agency), CNES (space agency of France) etc.
- Gaganyaan will play a vital **role** in boosting technological, educational and economic development within the country:

Technological, Educational and Economic Development:

- Gaganyaan will involve numerous agencies, laboratories, disciplines, industries and departments all of which are expected to learn and improve during this programme.
- Human Space flights are a frontier field in science and technology, and hence help in faster technological development.
- It will boost good research and technology development. With a large number of researchers with proper equipment involved, HSF will thrust significant research in areas such as materials processing, astrobiology, resources mining, planetary chemistry, planetary orbital calculus and many other areas.
- It will lead a Progress towards sustained and affordable human and robotic programmes to explore the solar system and beyond.
- Gaganyaan Programme is a national effort and will involve the participation of academia and National Agencies. It will establish a broader framework for collaboration between ISRO, academia, industry, national agencies and other scientific organizations.
- It will motivate younger generations to take up Space astronomy as a discipline in their career preferences.
- It will help in the improvement of industrial growth since many equipment will be required for its launch and training.

- The Indian industry will find large opportunities through participation in the highly demanding Space missions. Gaganyaan Mission is expected to source nearly 60% of its equipment from the Indian private sector. Recently, the Government has announced a new organisation, IN-SPACe, as part of reforms to increase private participation in the space sector.
- According to the ISRO chief, the Gaganyaan mission would create 15,000 new employment opportunities, 13,000 of them in private industry and the space organisation would need an additional manpower of 900.
- It will help in making India a Space hub.

Conclusion:

In terms of space technology, a manned space programme is the obvious next step for India. Gaganyaan success will put India into the elite club of space superpowers. It will help India to put a step forward in developing its own space station which the government plans to achieve after this mission success. The Gaganyaan will not only bring about prestige to the nation but also establish India's role as a key player in the space industry.

3. Neutrinos play a key role in many fundamental aspects of our lives. Elaborate on the significance and potential applications of Neutrinos. Also, highlight India's initiative in neutrino research.

Approach

1. Briefly introduce by defining the neutrinos
2. Highlight the significance and possible application of neutrinos
3. Highlight the initiatives taken by the government in this regard
4. Conclude with way forward

Hints:

Neutrinos are the second most abundant elementary particles in the universe after photons. Even though billions of them pass through us every second, we would not notice them because they rarely interact with matter. This property makes them one of the most elusive and mysterious elementary particles. On the other hand, they can traverse a vast distance without bumping into anything, which makes them an excellent probe for astrophysical phenomena deep in the universe.

Significance of neutrinos:

- Neutrinos assume significance and are very important for our scientific progress and technological growth for three reasons. First, they are abundant. Second, they have very feeble mass and no charge and hence can travel through planets, stars, rocks and human bodies without any interaction.
- In fact, a beam of trillions of neutrinos can travel thousands of kilometres through a rock before an interaction with a single atom of the rock and the neutrino occurs.
- Third, they hide within them a vast pool of knowledge and could open up new vistas in the fields of astronomy and astrophysics, communication and even in medical imaging, through the detector spin-offs.
- Neutrinos are the information bearers of the universe - which are almost never lost in their path. Neutrinos tell us a tremendous amount about how the universe is created and held together.
- Better understanding of neutrinos could unlock secrets about other elements of astronomy and physics, from dark matter to the expansion of the universe.
- They can teach us about the core of the densest stars, and could one day lead to the discovery of new astrophysical object

- Neutrinos are believed to be a vital ingredient in a star's supernova process. These explosions spread heavy elements throughout space, elements that are needed to create the universe we live in.
- Neutrinos also provide a tool to study the structure of nucleons (protons and neutrons), to learn how matter evolved from simple particles into more complex composites of particles, creating everything around us.

Possible Applications of neutrinos:

- Neutrinos may have a role to play in nuclear non-proliferation through the remote monitoring of nuclear reactors. Using appropriate neutrino detectors, the plutonium content can be monitored remotely and used to detect any pilferage. Neutrino research can be our answer to ensure that no terror group ever acquires nuclear weapons.
- Understanding neutrinos can help us detect mineral and oil deposits deep in the earth. Neutrinos tend to change their "flavour" depending on how far they have travelled and how much matter they have passed through in the way.
- Far more importantly, we believe that this same property might help us detect early geological defects deep within the earth, and thereby might be our answer to an early warning system against earthquakes.
- Neutrinos can pass right through the earth. They may open up a faster way to send data than the current 'around the earth' model, using towers, cables or satellites. Such a communication system using neutrinos will be free of transmission losses as neutrinos rarely react with the atoms in their path.
- This can open up new vistas for telecom and Internet services. Some scientists further believe that if there is any extra-terrestrial form of life, neutrinos will also be the fastest and most trusted way to communicate with them.
- Neutrinos are produced from radiation, so it might be possible for the International Atomic Energy Agency to use neutrino detectors to monitor which countries are following the treaty on the Non-Proliferation of Nuclear Weapons.

India's initiatives in Neutrino Research:

- India has been among the pioneers in neutrino research, the first of such laboratories having been established in the 1960s. We led neutrino research when our physicists used a **gold mine at Kolar in Karnataka** to set up what was then the world's deepest underground laboratory. This was called the Kolar Gold Field Lab. In 1965, it enabled researchers to detect atmospheric neutrinos. In 1992, when the mine became uneconomical, the laboratory was shut down. With that, we lost our advantage in understanding the most mysterious particle in the universe.
- Recently government has cleared the stalled national project, the **India-based Neutrino Observatory (INO)**, which is to study fundamental particles. The project, which involves the construction of an underground laboratory, under a rocky mountain in the Bodi West Hills region of Theni district, Madurai in Tamil Nadu.
- The neutrino is our mode of access to some of the most unimaginable technologies, and therefore, with INO, India is poised to take its rightful place at the helm of neutrino research. For example, the particle detectors developed for the neutrino experiment at INO can also be used to detect the photons in **positron emission tomography (PET)** which is used to identify cancerous tumours.
- India's effort in studying neutrinos at INO may help us unravel the deepest mystery of the universe - why there is more matter than antimatter in the universe..

Conclusion:

Thus, research on neutrino particle would be path breaking in the field of science and will help in knowing more about the universe. Successful research in this field would help Indian science address

key questions in neutrino physics and develop cutting-edge technology for particle detectors. However, all possible steps should be taken to address the apprehensions related to this project.

4. ***“Due to its precise data collection and accuracy, LIDAR is one of the most sought after technologies in the world today”. Discuss the significance of LIDAR technology for industrial, commercial, and scientific applications.***

Approach

1. ***In introduction, define LIDAR***
2. ***Discuss the significance of LIDAR technology***
3. ***Elaborate on how it works and discuss its applications and limitation in various fields***
4. ***Conclude, by suggesting way forward***

Hints:

Lidar, which stands for Light Detection and Ranging, is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. These light pulses—combined with other data recorded by the airborne system—generate precise, three-dimensional information about the shape of the Earth and its surface characteristics.

A lidar instrument principally consists of a laser, a scanner, and a specialized GPS receiver. Airplanes and helicopters are the most commonly used platforms for acquiring lidar data over broad areas. Two types of lidar are topographic and bathymetric.

How does a LiDAR system work?

- LiDAR follows a simple principle. A laser light is thrown at an object on the Earth’s surface and the time it takes for the light to return to the LiDAR source is calculated.
- Other elements which play an important role in the data collection and analysis are the photo detector and optics.
- Considering the speed of light, the process of determining the precise distance using LiDAR is incredibly fast.

Application of Lidar:

- **Structural and Civil Engineering:** LIDAR can be used to monitor construction progress in real time, compare those measurements to current schematics, and allow for updating of those schematics.
- **Self-driving technology:** Recent developments in LiDAR technology allows it to detect items up to 400 metres away, and even improve its capabilities in low light conditions.
- **Safety outfitting:** A robotic arm that handles heavy objects will be able to respond more keenly when a person-like object enters its path as opposed to an object that it was designed to handle.
- **Entertainment:** In movies or video games, for example, this allows for fluid 3D motion capture by human actors transcribed into a fictional universe that until now relied on expensive suits with sensors.
- **Agriculture:** It is possible to capture a whole crop’s growth in granular detail over time, provides important data and can inform on cultivation practices, both in real time and for future crops. LIDAR can also help optimize the movement of automated machinery in harvesting crops
- **Mapping Water Resource:** The Ministry of Environment, Forest and Climate Change used LiDAR for mapping out the water requirement within forest areas.
- **Map Development:** This technology is mostly used for ground-based surveys and the production of high-resolution maps.

- **Measuring Biomass:** It is used for calculating phytoplankton fluorescence and biomass in the surface of the ocean.
- **Mapping Ocean Floor:** Bathymetric lidar uses water-penetrating green light to measure seafloor and riverbed elevations.

However there are some limitations of LiDAR:

- High operating costs in some applications: Although LiDAR is cheap when used in huge applications, it can be expensive when applied in smaller areas.
- Ineffective during heavy rain or low hanging clouds because of the effects of refraction. However, the data collected can still be used for analysis.
- LiDAR technology does not work well in areas or situations where there are high sun angles or huge reflections since the laser pulses depend on the principle of reflection.
- LiDAR is a technology that collects very huge datasets that require a high level of analysis and interpretation. For this reason, it may take a lot of time to analyze the data.
- Elevation errors due to inability to penetrate very dense forests: In some instances where the canopies over the forests are dense, the LiDAR pulses may not be able to penetrate the canopies thus returning incomplete data.

Conclusion:

The true innovations behind the LiDAR units of today versus the earliest units in the 1970s are in the increasing miniaturization of the electronics components and the explosion of artificial intelligence and sensor connectivity over the last decade. LiDAR technology will prove itself invaluable in the coming years.

5. *The applications of Unmanned Aerial Vehicle (UAVs) are not limited to the military world; the usage has been expanding rapidly in many fields. Elaborate. Also, highlight some of the measures taken by the government of India to regulate the usage of drones.*

Approach

1. ***Briefly introduce with unmanned aerial vehicle and their applications***
2. ***Different techniques used to control rogue drones***
3. ***Drone regulations in India***
4. ***Way forward***

Hints:

An Unmanned Aerial Vehicle (UAVs) is an aircraft without a human pilot on board and a type of unmanned vehicle. The UAVs are commonly known as a drone, the components of UAVs include an unmanned aerial vehicle, and a ground based controller and communication system to connect the both of them. The UAVs are either operated by humans using a remote control or autonomously by themselves. The applications of drones have grown tremendously in the civilian and commercial industries over the past decade.

Applications of drone

Military use:

- An unmanned combat aerial vehicle (UCAV), also known as a combat drone, colloquially shortened as drone or battlefield UAV, is an unmanned aerial vehicle (UAV) that is used for intelligence, surveillance, target acquisition, and reconnaissance and carries aircraft ordnance such as missiles, ATGMs, and/or bombs in hardpoints for drone strikes. These drones are usually under real-time human control, with varying levels of autonomy.

- Unlike unmanned surveillance and reconnaissance aerial vehicles, UCAVs are used for both drone strikes and battlefield intelligence.

Other uses of drones

- **Aerospace:** Airlines and maintenance, repair, and operations contractors use UAVs for aircraft maintenance. In June 2015 Easy Jet began testing UAVs in the maintenance of their Airbus A320s and in July 2016 at the Farnborough Airshow, Airbus (manufacturer of the A320), demonstrated the use of UAVs for the visual inspection of an aircraft. However, some aircraft maintenance professionals remain wary of the technology and its ability to properly catch potential dangers.
- **Civil uses:** Civil uses include aerial crop surveys, aerial photography, search and rescue, inspection of power lines and pipelines, reconnaissance operations, border patrol missions, convoy protection, surveillance, coordinating humanitarian aid, plume tracking, land surveying, fire and large-accident investigation, landslide measurement, illegal landfill detection, the construction industry, smuggling, and crowd monitoring.
- **Conservation of flora and fauna:** UAV usage in conservation is able to alleviate many of the challenges facing conservationists on foot, such as “the large size of species’ geographic ranges, low population densities, inaccessible habitat, elusive behavior and sensitivity to disturbance.
- **Agriculture:** Gather data and automate redundant processes to maximize efficiency to spray pesticides and fertilizers, in planting, distribution of seeds.etc.
- **Health and medicine:** delivering quick access to drugs, blood, and medical technology in remote areas, transportation of organs during organ transplantation from donor to recipients.etc.
- **Weather forecasting:** drones can physically follow weather patterns as they develop to understand the environment and imminent weather trends in a better way.
- **Disaster management:** surveillance of disaster affected areas to assess damage, locate victims, and deliver aid.

Drone regulations in India

- As per Drone Rules, 2021, any person who intends to obtain the authorisation to establish a Remote Pilot Training Organisation (RPTO) shall submit an application to the Director General of Civil Aviation in Form D5 on the Digital Sky Platform, along with the specified fees.
- Under the drone regulation, the digital sky platform will enable online registration of pilots, devices, service providers, and NPNT (no permission, no take-off).
- The digital sky platform is a unique unmanned traffic management (UTM) system which is expected to facilitate registration and licensing of drones and operators in addition to giving instant clearances to operators (online clearances) for every flight.
- The airspace has been divided into different zones, they are:
 1. Red zone – Flying not permitted
 2. Yellow zone – Controlled airspace
 3. Green zone – automatic permission
- All civilian drone operations will be restricted to only during day time and a maximum of 400 feet altitude.
- Any human or animal payloads or anything hazardous cannot be carried by drones.
- Except drones used by the National Technical Research Organisation and central agencies, all the other would be registered and need to get unique identification number.

Drone (Amendment) Rules 2022

- Drone certification scheme was further notified 2022, making it easier to obtain type certificate by drone manufacturers. A number of initiatives were taken such as banning import of foreign drones and freeing up import of drone components and abolishing the requirement of a drone pilot license.

Drone regulation 2.0

- The government is working and brought out drone regulation 2.0 focussing on three important thresholds:
 1. Delivery of payloads
 2. Beyond visual line of sight
 3. Automate the air traffic management to the extent possible
- Under drone regulations 2.0, the drones will be tracked by computers through artificial intelligence.
- The current policy allows one drone pilot for each drone whereas, in the next set of regulations, one pilot can operate any number of drones.

Conclusion:

Drone enabled deliveries, air taxis and many other innovations will not be widely available for years, but when available they could be as disruptive as the advent of automobiles. Drones have immense potential apart from a few mentioned, the new policy initiative will open up many new and exciting applications that can propel India's economy forward. It can provide a strong impetus to all players in the drone ecosystem and place India among the global leaders.

