1. Highlight the achievements of ISRO in the area of indigenisation of technology.

Introduction:

Indian Space Research Organization (ISRO) was established in 1969. Since its beginning, ISRO has created a niche for itself in the space technology world through continuous low-cost innovations.

Body

Indigenization of Space systems:

India has made remarkable strides achieving 98 per cent indigenisation in launch vehicle technology and 60-70 per cent in satellite technology
ISRO is making desperate attempts to indigenizing current space technology. It is developing its own rockets, cryogenic engines, navigation, spy and communication satellites.

Some of **Achievements** are:

CHANDRAYAAN-2:

- Chandrayaan2 is a fully indigenous mission, which aims to place a robotic rover on the moon, is India's most complex and most ambitious. For the first time, it will shed light on a completely unexplored region of the Moon - its Southern Polar region.

GAGANYAAN :

ISRO has successfully demonstrated some of the technologies required for the mission such as:

- Space Capsule Recovery Experiment (SRE-2007),
- Crew module Atmospheric Re-entry Experiment (CARE-2014),
- GSLV Mk-III (2014),
- Reusable Launch Vehicle- Technology Demonstrator (RLV-TD),
- Crew Escape System
- Pad Abort Test (2018) and
- unveiled a space capsule (crew module) and Space suit prototype

IRNSS:

- India's own regional navigation satellite system named as "Navigation with Indian Constellation (NavIC)" is established by ISRO
- The potential of this indigenous system is being demonstrated in various application sectors viz. vehicle tracking system, mobiles, timing & power synchronization, fisheries, surveying etc. For example, all commercial vehicles

registered from 1stApril 2019 onwards are mandated to have vehicle trackers, which are also NavIC-enabled.

GAGAN:

- The Indian Space Research Organization (ISRO) and Airports Authority of India (AAI) have implemented the GPS Aided Geo Augmented Navigation-GAGAN project as a Satellite Based Augmentation System (SBAS) for the Indian Airspace. The objective of GAGAN to establish, deploy and certify satellite based augmentation system for safety-of-life civil aviation applications in India has been successfully completed.

MANGALYAAN:

- It is India's first interplanetary mission and made ISRO the fourth space agency to reach Mars, It made India the first Asian nation to reach Martian orbit and the first nation in the world to do so in its maiden attempt. most of the systems were indigenous.

HysIS:

- It is the country's first hyperspectral imaging satellite for advanced Earth observation. HysiS is a state-of-the-art satellite with many indigenous components developed by SAC.
- The primary goal of HysIS is to study the Earth's surface in visible, near-infrared and shortwave infrared regions of the electromagnetic spectrum.

LAUNCHERS:

- Launch Vehicles are used to carry spacecraft to space. India has two operational launchers: Polar Satellite Launch Vehicle (**PSLV**) and Geosynchronous Satellite Launch Vehicle (**GSLV).**

ENGINES:

- ISRO is also planning to use **scramjet engine** for minimizing rocket size (40-50 per cent) and save fuel (up to 70 per cent). Furthermore, ISRO has developed RLV-TD a reusable launch vehicle to make space program cheaper and perform advanced space research.
- GSLV Mark III – developed by ISRO with its **own cryogenic engine**. The launch vehicle is capable of carrying 4 ton satellites into the geosynchronous transfer orbits.

DEFENCE:

- Communication is key to any sort of defence establishment. By developing India's capability in GSLV launching system, India is now inching closer to launching its own communication satellites which will serve a critical role and purpose in times of strategic need.

In all, India now has complete autonomous capability in space technology- propellant manufacture, satellite manufacture, launch capability up to 4ton satellite and so on. Also, the costing is very competitive compared to foreign launches which costed much more, thereby saving India's foreign reserve too

Conclusion:

The success of ISRO is testament to India's capability in frugal engineering and finding solutions with severe resource constraints and international non-cooperation. Future missions like Aditya-L1, Gaganyaan etc. will help India enhance its global image even further.

2. What are some of the breakthrough innovations carried out by Indian scientists? Discuss.

Introduction:

Very less is known to world about India's contribution towards Scientific and technological innovations. The greatness of Indian innovations goes back to ancient India which was known for rich scientific contributions right from the use of zero, precise calculation of eclipses, concept of atom, to "Shushruta Samhita" involving complex surgery and "Charak" explicitly describing diseases, their causes and modes of treatment.

Body:

Break through innovations carried out by Indian scientists:

- Brahmagupta was the first to give rules to compute with zero.
- Varahamihira's main work in the book Pancha-Siddhantika on mathematical astronomy.
- Susrutha is widely regarded as the most ancient surgeon of the world. He was the inventor of the art of Plastic surgery and is regarded as the 'Father of Plastic Surgery'.
- Ajay V. Bhatt is an Indian-American computer architect who helped define and develop several widely used technologies, including AGP (Accelerated Graphics Port), PCI Express, Platform Power management architecture and various chipset improvements. He is mostly famous for the invention of the USB technology on which the modern storage devices such as pendrive works.
- Chemistry professor Rajagopalan Vasudevan devised a way to transform common plastic litter into a substitute for bitumen — the main ingredient in asphalt used for road construction. Known as the "Plastic Man," Vasudevan's indigenous invention has already paved 3,000 miles (5,000 kilometers) of plastic thoroughfares in at least 11 Indian states.

- Narinder singh is an Indian-born American Sikh physicist known for his work in fibre optics. He was named as one of the seven 'Unsung Heroes' by Fortune magazine in their 'Businessmen of the Century' issue. His innovations in the technology of fiber optics changed the communication industry. He is also known as "Father of Fiber Optics". He was officer in Indian Ordinance before moving to USA.
- Meghnad Saha is known for the thermal ionisation of elements, and it led him to formulate what is known as the Saha Equation. This equation is one of the basic tools for interpretation of the spectra of stars in astrophysics. By studying the spectra of various stars, one can find their temperature and from that, using Saha's equation, determine the ionisation state of the various elements making up the star. It is used in studying the physical and chemical state of stars.
- Satyendra Nath Bose was an Indian physicist specializing in mathematical physics. He is best known for his work on quantum mechanics in the early 1920s, providing the foundation for Bose–Einstein statistics and the theory of the Bose–Einstein condensate.
- J C Bose, pioneered the study of radio and microwave optics, made important contributions to the study of plants and laid the foundation of experimental science in the Indian sub-continent. He was the first person to use semiconductor junctions to detect radio signals, thus demonstrating wireless communication for the first time.
- Dr. Suryasarathi Bose, Assistant Professor of Department of Materials Engineering and a team invented a water purifying system that could even eliminate harmful bacteria at a nanoscale level.
- A non-invasive device that can measure heart and lung, called the Fibre Bragg Grating Heart Beat Device, was invented by S Asokan, Professor at Department of Instrumentation and Applied Physics and his team. The device simply needs to be wrapped around a person's chest, while the sensors detect cardiac activities, measure blood pressure, count blood glucose levels, and monitor respiration. Made of an optical fibre sensor, this device can easily help detect heart conditions early.
- In 2012, Sathees C Raghavan, associate professor with IISc's biochemistry department and his team developed a molecule inhibitor, SCR7, which could revolutionise cancer treatment.
- Another twist to the water purifier, this innovation by Professor Vasant Natarajan, from the Department of Physics is low cost and does not require membranes or electricity. According to Natarajan, this device could purify all kinds of water – sea, bore well, ponds, even rain water – into drinkable water, and produce 1.5 litres out of 3 litres of impure water.
- Lastly, a name that needs no introduction. He is probably the greatest scientist of Modern India. Nicknamed as 'Missile Man'. For four decades he worked as a scientist and science administrator, mainly in DRDO and ISRO. His work on the development of ballistic missile and launch vehicle technology made it possible for India to develop its defense and be independent of foreign Tech. He also played a prominent role in

India's Pokhran-II nuclear tests in 1998 for which he was also awarded Bharat Ratna.

Conclusion:

This legacy of innovations needs to be further taken forward because innovation is the one and only medium that can provide solutions for the present and emerging problems in the years to come. Government has taken number of steps to encourage development of scientific temper through schemes such as AIM (Atal Innovation Mission), INSPIRE and revive the traditional Indian knowledge through schemes such as AYUSH mission.

3. What are the strategic implications of indigenising space technology? Examine.

Introduction:

Space technology has become an essential part of daily life and it's hard to picture what a life without space tech would be like. Vast is the range of spin-off benefits derived from the advancement of space technology such areas as mapping the natural resources through remote sensing, telecommunication, television and weather forecasting.

Body:

Indian Space Agency ISRO is making desperate attempts to indigenizing current space technology. It is developing its rockets, cryogenic engines, navigation and communication satellites.

The Indian space scientists have contributed a lot to the indigenization of space technology. Some remarkable achievements in recent times have been the launching of CHANDRAYAAN-2, A-SAT, IRNSS (NavIC), MANGALYAAN, GSLV Mark III to name a few.

The strategic implications of indigenising space technology:

- **Autonomy:** Indigenization leads to less dependency on other countries to launch communications satellites. Dependency on foreign suppliers produces helplessness like the high cost of maintenance and inventories and the danger of deficit of spares later in the life cycle. Dependency curbs strategic autonomy.
- **Enhanced Global image:** Advancement in indigenous space technologies leads to the enhanced global image of the country.
- **Data Security:** Sensitive data such as military operations will be limited to the home country only. Eg. India will now use its navigation system NavIC instead of GPS made by the US.

- **Real-Time Data:** Country will get real-time data for weather and military purposes without relying on other countries which may have vested interests.
- **Improved bilateral relations:** Indigenization of space technology improves bi-lateral relation with countries who don't have these advanced technologies and want to launch their satellites.
- **Support to Neighboring Countries:** India can provide telecommunication and navigation services beyond Indian boundaries catering to the population of South East Asia to the Middle East.
- **Recognition in global forum:** Self-sufficiency of information and indigenous space technology will give voice and recognition to the country on global forums.
- **Commercial Gains:** Till now, India has paid commercial rates to other countries to launch its communications satellites. Now India can commercially produce and even launch a satellite for other countries and can in-cash the indigenously developed world-class capabilities.
- **Suitability with local needs:** Technology can be developed as per local and regional needs. Ex. NavIC can be used in regional languages, unlike GPS which has limited language options.

Conclusion:

It is a well-established that no nation can become hopeful to attain a great power status without being practically self-reliant in space technology. In the long run, given the geopolitical realities, 100% Indigenization of space tech has to be a core strategic policy for India.

4. Critically assess the performance of India's defence PSUs.

Introduction:

Indian defence sector aims to promote self-reliance, indigenisation, developing capabilities for export, transfer of technology and domestic R&D. GOI has thus established nine Defence Public Sector Undertakings (DPSUs) whose responsibility is to provide the Armed Forces state-of-the-art equipments and at the same time enhance country's self-reliance in defence production.

Body:

Positive performance of the Defence PSUs (DPSUs):

- **Self-reliance**: DPSUs have successfully delivered equipments to several defence and national projects in the recent times.
    - Hindustan Aeronautics Limited (HAL) delivered the Orbiter Craft Module Structure to ISRO Satellite Centre (ISAC) for the Mars Orbiter Mission (Mangalyaan).

  - Bharat Dynamics Limited (BDL) has integrated LRSAM missile for Indian Navy and two LRSAM Missiles have been test fired successfully from Indian Warships.
  - Mazagaon Dock Shipbuilders Limited (MDL) currently is constructing Missile Destroyers, Stealth Frigates (P-15 B destroyers and four P-17A stealth frigates) and Scorpene Submarines (INS Kalvari, INS Vela).
  - Garden Reach Shipbuilders and Engineers Limited (GRSE) is working on 14 warships, including two Antisubmarine Warfare Corvettes (ASWC), eight Landing Craft Utility (LCU) ships and four Water Jet Fast Attack Crafts (WJFAC).

- **Undertakes construction of allied items of defence equipments and Atomic Energy for the country:**

  - Bharat Electronics Limited (BEL) has core competencies in areas of Radars &Weapon Systems, SONARs, Communication, EWS, Electro-Optics and Tank Electronics.
  - Goa Shipyard Limited (GSL) is well-known for designing indigenously and building sophisticated high technology ships for Indian Defence Forces and other varied clients including export markets.
  - Hindustan Shipyard Limited (HSL) has plasma cutting machines, steel processing and welding facilities, material handling equipment, cranes, and logistics and storage facilities.

- **Economic contribution:** 41 Ordnance Factories and 9 DPSUs in our country contributing to more than Rs.58000 crores approx. in defence production every year. Defence Public Sector Undertakings have achieved the turnover of Rs.45776 crores in 2018-19.

However, recent reports including by the CAG in 2016, provide a disappointing picture in several aspects related to DPSUs:

- **No considerable reduction in import**: India ranks the highest in import of defence equipment, spending annually on an average about $3.6 billion. Only about 35% of defence equipment is manufactured in India, mainly by the PSUs. Moreover, even when defence products are manufactured domestically, there is a large import component of raw material at both the system and sub-system levels.
- **Lack of notable contribution to self-reliance:** Except for missilery, communication systems and some low technology items, DPSUs have not contributed notably to self-reliance in defence production. Its production profile reveals that most of them are over-dependent on external sources for the production needs, and have a very low labour productivity level.
- **Delay in completion**: CAG report showed that inordinate delay in supply of critical weapons and equipment had hampered the modernisation and capability enhancement plan of Indian Army, impacting the defence preparedness.

- **Financial implications**: The delay had financial implications towards loss of interest on payments made to DPSUs. Example: Delay in critical equipment like Akash missile system and a weaponised version of the Advanced Light Helicopter, suffered a loss of Rs 1,931 crores on account of accrued interest on advance paid to the DPSUs.
- **Low accountability**: The absence of accountability and the presence of political interference are high. For example, BEML's indigenised Bofors howitzers project went into cold storage due to political compulsions in the late 1980s.
- **Low Research and Development capacity and low exports.**

What has been done to address these shortcomings?

- FDI Policy has been revised and under the revised policy, FDI is allowed under automatic route up to 49% and beyond 49% through Government route.
- The Defence Products List for the purpose of issuing Industrial Licenses (ILs) under IDR Act has been revised so as to reduce the entry barriers for more than 8000 MSMEs which are among the vendor base of OFB & Defence PSUs supplying various items to them.
- An innovation ecosystem for Defence titled Innovations for Defence Excellence (iDEX) aimed at creation of an ecosystem to foster innovation and technology development in Defence and Aerospace to carry out R&D.
- NITI Aayog and the NSAB recommended a restructuring of all defence PSUs under a single body that can be governed by a different ministry, like the Ministry of heavy industries and public enterprises.
- Several projects have now been kept on a competitive basis, in which both PSUs and private industry are participating.

Way forward:

- Facilitation: A directory of credible defence manufacturers should be made available to all the defence procurement agencies and foreign producers to locate potential Indian partners for collaboration.
- As suggested by Kelkar committee, government should identify certain firms based on their technical, managerial and financial strength as "champions" ("Raksha Udyog Ratna") irrespective of being private players.
- Focus more on indigenous defence technology development rather than on development only by PSUs, by appropriate funding of researches and hiring skilled manpower by DRDO and other state and private owned entities in defence.
- Private sector: Treat them as equal partners and offer them big projects to boost their capabilities ensuring adequate transparency.

Conclusion:

Defence industry is highly technology driven and it is the private sector that adapts itself better to rapidly changing technology. 'Make in India' for defence can be encouraged with equal help and advanced technical know-how of the private players along with the combination of public enterprises to reap out the best of both sides.

5. What is the status of research, development and innovation in Indian universities? What suggestions would you give to improve the situation?

Introduction

India is spending stagnant of 0.6 to 0.7 in terms of percentages of GDP on research and development according to economic survey. It suggested for doubling national expenditures on R&D. According to Times Higher Education (THE) Emerging Economies University Rankings, 49 institutions have made it to the list. Of these, 25 institutions have been included in the list of top 200 universities.
According to WIPO, India is the seventh largest patent filing office in the World.

Body

Status of research and development in Indian universities:

- India has no firms in five of the top ten R&D sectors as opposed to China that has a presence in each of them.
- About three-fifths of government's investment in R&D is spread over the key government science funding agencies like Atomic Energy, Space, Earth Sciences, Science and Technology and Biotechnology.
- Government expenditure on R&D is undertaken almost entirely by the central government.
- The survey also pointed out that there has been an increase in the number of enrolments in Ph.D with 1.26 lakh students.
- The gross expenditure on R&D (GERD) was mainly driven by the government sector with central government accounting for 45.1 %, state governments 7.4 %, public sector industries 5.5 % and institutions of higher education 3.9 %. The private industry accounted for the balance 38.1 %.
- The public sector R&D was led by defence related industries and fuel industry, while the private sector R&D was dominated by drug and pharmaceuticals and transportation.
- India topped the list with regard to the government's participation in R&D but hit the bottom in terms of participation of institutions of higher education.
- Women's participation in extra mural R&D projects has increased significantly from a mere 13 % in 2000-01 to 29 % in 2014-15.
- Only 15 researchers per 100,000 people, putting India among the bottom five countries on this yardstick. Not only is the quantum of research poor, but also the quality of research.

Status of innovations in Indian universities:

- India secured 52nd rank in global innovation index.
- This list includes 127 countries ranked on parameters like infrastructure, market sophistication, business sophistication, institutions, and human capital and research.
- Judging the innovative capacities of India is that many innovations of the informal sector go unnoticed.
- India does not have a technology transfer legislation that would enable the transfer of know-how from university research labs to the private sector for commercialization.
- Many of India's innovations are not easily captured in indicators. Bangalore, for example, ranks at 65 among the top clusters in the world. Since the city's innovation is based on software, it does not show up in patents and publishing.

Measures to improve situation:

- To improve the quality of research institutes, for the promotion of technology business incubators (Atal Incubation Centres) and research parks that promote innovative ideas until they become commercial ventures.
- Atal Tinkering Labs ensure that dedicated workspaces are created for students to innovate and develop ideas that will go on to transform India
- Government procedures and approvals for scientists and researchers have been placed online and made transparent, thereby assuring "Ease of Doing Science".
- Unnat Bharat Abhiyan 2.0 to help bring transformational change in rural development processes by leveraging knowledge institutions to help build the architecture of an Inclusive India.
- Ucchtar Avishkar Yojana (UAY), Ramanujan Fellowship Scheme, the Innovation in Science Pursuit for Inspired Research (INSPIRE) Faculty scheme and the Ramalingaswami Re-entry Fellowship, Visiting Advanced Joint Research Faculty Scheme (VAJRA), GIAN, can act as a catalyst in leveraging the scientific diaspora.
- RUSA, RISE, IMPRINT and Institutions of eminence are some other steps taken by Central Government to enhance the quality and competitiveness of higher educational institutions.

Conclusion

Research and development, innovations are important at all stages of development; specifically, the creation and diffusion of technologies are important for economic growth and welfare across all economies.