1.Examine the contribution of Indian scientists in the field of Physics.

Introduction

From C. V. Raman to Salim Ali, the talents of Indian scientists and inventors have been fully established in many different areas, including physics, medicine, mathematics, chemistry and biology. Some of them have also contributed in a substantial way to advanced scientific research in many different regions of the world.

Body

The contribution of different Indian scientists in the field of Physics

- **C. V. Raman**: Sir C.V. Raman is known to have placed India on the world Science map. He was the first person from Asia to be awarded a Nobel Prize in any field of science for his work on *Raman Effect.* The Raman effect has been very useful in many areas of science. It was found that when light was passed through a substance, a series of colours were seen that could be thought of as a fingerprint of the substance. This idea has been used in chemistry, medicine, biology and many other areas of science to find out what a substance is made of.
- **Homi Jehangir Bhabha**: Bhabha's name is associated with Bhabha Scattering, which involves relativistic exchange scattering of electrons and Bhabha-Heitler theory, dealing with production of electron and positron showers in cosmic rays.
  Bhabha was instrumental in the formation of the Atomic Energy Commission in 1948 and the Department of Atomic Energy in 1954 and he chalked out a focussed research and minerals exploration programmes for nuclear energy. He became its first head. India's First atomic reactor, Apsara was also established under his guidance, thus he is known as Father of Nuclear Science in India.
  In 1950s, he enunciated a three-stage nuclear programme to meet the energy security of the nation. This consisted of utilization of natural uranium, plutonium and abundant thorium resources in thermal, fast and advanced nuclear reactors with closed fuel cycle.
- **Vikram Sarabhai**: The precursor to the current ISRO, Indian National Committee for Space Research (INCOSPAR) was set up in 1962 under Dr. Vikram Sarabhai to formulate the Indian Space Programme. Under Dr. Sarabhai, INCOSPAR took the decision to set up Thumba Equatorial Rocket Launching Station (TERLS) at Thumba on the southern tip of India.
  In 1963, under his guidance, India launched a small U.S.-built rocket from Thumba. This rocket did no more than shoot up to a height of about 200 km and release a cloud of sodium vapour which, set aglow by the light of a setting sun, could be seen from afar in the gathering dusk. This was the

humble beginning of India's space programme and Dr. Vikram Sarabhai is thus called father of Indian Space Programme.

As a result of Dr. Sarabhai's dialogue with NASA in 1966, the Satellite Instructional Television Experiment (SITE) was launched during July 1975 - July 1976 (when Dr.Sarabhai was no more).

Dr. Sarabhai started a project for the fabrication and launch of an Indian Satellite. As a result, the first Indian satellite, Aryabhata, was put in orbit in 1975 from a Russian Cosmodrome.

- **Jagdish Chandra Bose**: Bose was a pioneer in the field of electro-magnetic waves and is widely regarded as the first scientist who demonstrated the phenomenon of wireless transmission of electromagnetic waves.
- **Ashoke Sen**: Dr. Sen's work on 'strong-weak coupling duality', which is useful for doing calculations in theoretical physics, won him the first ever 'Fundamental Physics Prize'.
- **A.P.J. Abdul Kalam**: Dr. Kalam was the project head of the Satellite Launch Vehicle (SLV-3). This was India's first experimental Satellite Launch Vehicle which put the satellite Rohini into orbit. As a director of DRDO, he steared the Integrated Guided Missile Development Programme (IGMDP), and five projects viz. Prithvi, Trishul, Akash,Nag and Agni were developed under him. APJ Abdul Kalam is known as the *"Missile Man of India"* for his contributions on the development of ballistic missile and launch vehicle technology.
- **Satyendra Nath Bose:** Satyendra Nath Bose did path-breaking work on quantum mechanics in the early 1920s, using maths to describe the behavioural pattern of the bosons. Bose worked with Einstein providing the foundation for Bose-Einstein statistics and the Bose-Einstein condensate. Bose figured out how a group of identical photons would behave. He sent his paper to Albert Einstein who recognized the value of his research work and extended it further under the name of Bose-Einstein Statistics. The particles such as photons that obey these statistics are called bosons.

  One of the most dramatic effects of Bose-Einstein statistics is the prediction that bosons can overlap and coexist with other bosons.
- **Venkatraman Radhakrishnan:** He was a globally famous space scientist and was a member of the Royal Swedish Academy of Sciences.

  He was known for his works for the design and fabrication of ultralight aircraft and sailboats. His observations were helpful in unraveling the mysteries of galaxy structures, interstellar clouds, and other celestial bodies.
- **Subrahmanyan Chandrasekhar:** He was known for his works in Physics, astrophysics, and applied mathematics. Chandrasekhar was awarded the Nobel Prize for Physics for his mathematical theory of black holes. The *Chandrasekhar limit* is named after him. He was known for his works on radiation of energy from stars especially from white dwarf stars i.e. the dying fragments of stars.
- **Meghnad Saha:** He worked in the arena of thermal ionization of elements and later developed the Saha equation. The equation is used for interpreting spectra of stars in Astrophysics. He has been credited for inventing an instrument for measuring the weight and pressure of solar rays. He was the

chief architect of the river planning in India and prepared the plan for the Damodar Valley project.

- **PK Iyengar:** He was an Indian nuclear physicist who is widely known for his central role in the development and design of the first atomic bomb for the nuclear program of India which was detonated at Pokhran in 1974.
- **Dr. Tessy Thomas:** Dr. Tessy Thomas, also known as "*Missile Woman of India"* is the Key Scientist for Agni-V in Defence Research and Development Organisation. She is the first woman scientist to head a missile project in India.
- **Atish Dabholkar:** Atish Dabholkar, a theoretical physicist from India is known for his research on string theory and quantum black holes.
- **Nandini Harinath:** Nandini Harinath - a rocket scientist at ISRO, Project Manager, is a Mission Design Deputy Operations Director, Mars Orbit Mission and the Mission system leader of NISAR, a joint NASA-ISRO satellite being developed to launch in 2020.
- **Rohini Godbole:** She is a particle physicist best known for her work at CERN, European Organization for Nuclear Research. Her work on high energy photons could form the basis for the next generation of particle colliders, used to study the fabric and composition of the Universe.

Conclusion

To summarize, Indian scientists have contributed astonishingly in the growth of India. They have augmented the status of India with their scientific achievements and many of the Indian scientists have also received some prestigious international awards as well. The discoveries of the Indian scientists have been appreciated all over the world.

2. The Indian Space Research Organisation (ISRO) has set high standards in the area of space technology. Discuss.

Introduction

Formed in 1969, ISRO is one of the successful organizations which took the space explorations to a new level in terms of technology as well as its utility for national development.

Body

Setting high standards in space technology:

With limited resources compared to space organizations like NASA or ESA, ISRO being rich in human capital has set milestones in the area of space technology putting itself in the league of space elites.

- ISRO space launches has one of the high success rates in space launches and also at low cost which makes it trustworthy for other countries to launch their satellites using ISRO space vehicles. This has also added to the soft power diplomacy of India.
- The cost of launch by ISRO is far less compared to other space agencies. ISRO has been a pioneer in launch of small satellites and is servicing the other countries.
- ISRO Created a world record by launching 104 satellites in single mission in 2017.
- India became only the 6th country to be successful in mission to moon when it launched Chandrayaan in 2008. The data collected by it confirmed the presence of liquid in moon which corroborated NASA and ESA's missions on moon.
- India's MOM/Mangalyaan mission cost was only 11% that of the NASA's mars mission MAVEN and was launched with the help of PSLV. MOM had a budget of just Rs. 450 crores, making this Mars mission the least expensive till now. Also, India is the only country to be successful in mars mission at the very first attempt.
- ISRO is making advancement in Astrobiology as well. Three bacteria species that have a high resistance to the UV-rays were found in the earth's upper stratosphere, in 2009 by ISRO.
- ISRO launched GSLV-MK3 on December, 2014, that has an Indian made crew capsule which can carry up to three astronauts to space.
- ISRO, over the years has developed technologies indigenously which were denied to it by developed countries. E.g. GLSV F-09 launched in 2017 used upper cryogenic stage whose supply was denied by Russia. ISRO developed IRNSS/NAVIC after USA restricted access to GPS during Kargil war.
- India's Gaganyaan mission is set to be launched by 2022. The required tests like Space capsule Reentry Experiment, Pad Abort Test etc., are being tested at an accelerated pace.
- ISRO is at par with the advanced space agencies in terms of latest technology developments like Reusable Launch Vehicle Technology Demonstrator (RLV-TD), Scramjet etc.,
- ISRO is at the forefront in space exploration with collaborations with other space agencies like the NISAR mission setting a standard in international space diplomacy in joint explorations.
- ISRO has been pioneer in nano-satellites development and is training 45 countries in the same which includes Brazil, Indonesia, Malaysia and so on. India has been a champion in sharing space technology with the developing and underdeveloped countries.
- Space technology for development: ISRO has undertaken development projects like Village Resource Center and so on has demonstrated the use of space investment in country's development.
- Programmes of ISRO like UNNATI, Yuvika is setting new standards to tap the young minds towards space exploration as a career option. Also, the

increasing opportunities and latest missions in ISRO is arresting the brain drain.

Conclusion

As our prime minister observed – ISRO is the pride of the nation which showed us that sky is the limit and it is in our limits. From using space technology for development to advanced space missions and explorations, ISRO has set new milestones for developed countries and has set new standards for developing countries to take leap in space technology.

3. Indian women have come in the forefront of astounding scientific achievements. Do you agree? Substantiate.

Introduction

Prior to Indian independence, the numbers had been very low, even as a fraction of those who studied science. Since then however, Indian women have come a long way in terms of science education. Today they form almost 40% of the undergraduates in science, with engineering close second. Even among the Ph.D.'s in science, about 25-30% are women. There is a fair distribution among different subjects, with life sciences and chemistry dominating.

Body

Recent women scientist's achievements

- For the first time in India's space mission history, the ISRO expedition was spearheaded by two women. While **Muthayya Vanitha** is the project director, **Ritu Karidhal** is the mission director of Chandrayaan-2.
- **Chandrima Shaha** is an Indian biologist, currently Professor of Eminence at the National Institute of Immunology. She is the former Director of the Institute. She is President – Elect of the Indian National Science Academy.
- **Tessy Thomas**is an Indian scientist and Director General of Aeronautical Systems and the former Project Director for Agni-IV missile in Defence Research and Development Organisation. She is the first woman scientist to head a missile project in India
- **Indira Hinduja** – An Indian gynaecologists and infertility specialist based out of Mumbai, Indira is the first to deliver a test tube baby in India.
- **Paramjit Khurana Paramjit** is a scientist in the field of Plant Biotechnology, Genomics, and Molecular Biology. She has published over 125 scientific papers
- **Nandini Harinath** – A rocket scientist at the Indian Space Research Organisation (ISRO) Satellite Centre in Bengaluru, Nandini has worked on 14

missions in her 20 years of work. She was the deputy operations director for the Mangalyaan mission.

- **Rohini Godbole Rohini** is an Indian physicist and a professor at the Centre for High Energy Physics of the Indian Institute of Science in Bengaluru. She has worked for over three decades on Particle Phenomenology, and is particularly interested in exploring the Standard Model of Particle Physics (SM).

Although Indian women are not perceived as being incapable of doing science and engineering, their representation in these fields is small – the generic scientist is still perceived to be male. There are efforts to change this perception, but the change is slow, and there are few women scientists in positions of administrative power, namely as Institute Directors or University Vice Chancellors.

Apart from the Department of Biotechnology (DBT) and the Indian Council of Medical Research (ICMR) the percentage of women faculty is woefully low, particularly when one considers positions of Associate Professors and above. Percentage of women on the faculty of the high profile institutes like TIFR (Tata Institute of Fundamental Research), the IITs, or IISc is about 10-12%.

Conclusion

It is unfortunate that gender bias occurs even in a field like science, which is supposed to be objective and free of prejudices. Fortunately, winds of change are blowing - slowly but surely.

4. Discuss the distinguished contribution of Vikram Sarabhai in the field of science.

Introduction

Dr. Vikram Ambalal Sarabhai is a renowned Indian physicist. Dr. Sarabhai's contributions in space research gave him recognition as the Father of the Indian space program. He was the innovator and creator of a number of institutions in the varied fields including but not limited to space, nuclear energy, arts, education, and management. He was honored with Padma Bhushan in 1966 and the Padma Vibhushan in 1972.

Body

His important contribution includes –

- Initiation of space research and development of nuclear power in India. He convinced the Government of India to form the Indian National Committee for Space Research (INCOSPAR) in 1962 and was the first chairperson of the

committee. INCOSPAR was later renamed as Indian Space Research Organisation (ISRO) in 1969. He played an advisory role in the new setup.

- Vikram Sarabhai founded the Physical Research Laboratory (PRL) in Ahmedabad on November 11, 1947. He was only 28 at that time.
- He was also Chairman of the Atomic Energy Commission.
- He played a major role in the creation of the Indian Institute of Management, Ahmedabad.
- Some of the other most well-known institutions established by Dr. Sarabhai are:
    - Community Science Centre, Ahmedabad
    - Vikram Sarabhai Space Centre, Thiruvananthapuram
    - Space Applications Centre, Ahmedabad
    - Faster Breeder Test Reactor (FBTR), Kalpakkam
    - Varaiable Energy Cyclotron Project, Calcutta
    - Electronics Corporation of India Limited (ECIL), Hyderabad
    - Uranium Corporation of India Limited (UCIL), Jaduguda, Bihar
- As a result of Dr. Sarabhai's dialogue with NASA in 1966, the Satellite Instructional Television Experiment (SITE) was launched.
- Dr. Sarabhai started a project for the fabrication and launch of an Indian Satellite. As a result, the first Indian satellite, Aryabhata, was put in orbit in 1975 from a Russian Cosmodrome.

Conclusion

We can say that the contributions made by Dr. Vikram Sarabhai are extraordinary in the field of space science. His dedication and hard work can't be forgettable and so, to pay homage to the father of India's Space program, ISRO has announced an award in the name of Vikram Sarabhai on his 100th birthday on 12 August, 2019.

5. India has produced some of the most talented engineers that the world has seen. Can you discuss the contributions made by at least three such engineers?

Introduction

Indian engineers are renowned for their research and skills worldwide. Engineering in India can be traced to ancient civilizations. Engineers of ancient India were responsible for designing everything from complex water supply and drainage systems used by the extinct Harappa and Mohenjo Daro civilizations. This is reflected till present day with extensive contribution from Indians in engineering field.

Body

- The country is undergoing industrialization and working towards self-reliance in almost every sphere. The Indian government rightly deserves full credit for advancing meaningful research of engineering and science in India.
- India is home to some of the best engineering colleges in the world. These include College of Military Engineering, Indian Institute of Technology, National Institute of Technology and Indian Institute of Space Science and Technology, among others.
- Modern initiatives like 'Make in India' and 'Skills India' are providing a great platform for developing the industrial base of this country by promoting indigenous technologies and research as well as advanced skills required by foreign companies and other organizations that are eyeing investments in this country.
- According to a report published by global researcher and publisher, Elsevier, institutional collaboration in India accounted for 46 percent of impressive research and scholarly output while 16 percent was through tie-ups with foreign universities, companies, and other organizations.

India has produced many eminent engineers since ages, some of them can be as seen below :

- Mokshagundam Visvesvaraya - was an Indian engineer, scholar, statesman and the Diwan of Mysore from 1912 to 1918. He is a recipient of the Indian Republic's highest honour, the Bharat Ratna, in 1955. He was knighted as a Knight Commander of the British Indian Empire by King George V for his contributions to the public good. Every year, on his birthday, September 15 is celebrated as Engineer's Day in India. He is held in high regard as a pre-eminent engineer of India. He was the chief engineer responsible for the construction of the Krishna Raja Sagara dam in Mysore as well as the chief designer of the flood protection system for the city of Hyderabad.
- E Sreedharan - He is known as the Metro Man of India. He was a retired Indian Engineering Service (IES). He has done a lot to improve public transport in India. He received his secondary education at Basel Evangelical Mission Higher Secondary School. He completed his Civil Engineering from theGovernment Engineering College, Kakinada, Andhra Pradesh known as JNTUK. Commonly known as the 'Metro Man,' Mr Shreedharan is the most-renowned civil engineer India has produced in the past few decades. His work with the Delhi Metro, the Kolkata metro, and many more metro projects across the country are well documented, making his moniker a well-deserved one.
- A P J Abdul Kalam - He is known as the missile man of India. He also served as the 11th President of India from 2002 to 2007. APJ Abdul Kalam was born on 15 October 1931 at Rameswaram on Pamban Island, then in the Madras Presidency. He graduated from the Madras Institute of Technology in 1960. Then he joined the Aeronautical Development Establishment of the Defence Research and Development Organisation (DRDO) as a scientist. Kalam died on

27 July 2015 while delivering a lecture on "Creating a Livable Planet Earth" at the Indian Institute of Management Shillong.

- Satish Dhawan - He is known as the father of experimental fluid dynamics research in India. Dhawan was born in Srinagar on 25 September 1920. He graduated from University of the Punjab in Lahore (now Pakistan) where he completed a Bachelor of Science in Physics and Mathematics, a Bachelor's degree in Mechanical Engineering. To honour his works in rural education, remote sensing and satellite communications satellite launch centre at Sriharikota, Andhra Pradesh was renamed the Satish Dhawan Space Centre.
- Vinod Dham - He is known as the Father of Pentium microprocessor chip, a very popular term in the computer world. Vinod is also co-inventor of the flash memory technology, popularly known as SD cards widely used in USB drives, digital cameras, and many other storage devices. He holds a graduation degree in Electrical Engineering from Delhi College of Engineering. Presently Vinod is founding MD of Indo-US Venture Partners, an investment company with a focus on investing in Indian companies & start-ups of varied sectors. He is one of the top engineers in India

But at the same time, a recent survey carried out by Aspiring Minds has revealed that only 7% of engineering graduates in India are employed. According to this same report, only 3% of engineers in India have the suitable skills required to get a job in core sectors of engineering. Around 1.5 million engineers in India are released every year from various colleges but most of them simply do not have the skills required to be employed.

Conclusion

It is very unfortunate that the US imports most of the engineers from India when our own country is facing the crisis of quality and skills. Today, the market is looking for qualification along with certification. So, it becomes important for engineering institutions (especially private institutions) to create quality engineers instead of just giving away certificates. Today's India needs an engineer like Visvesvaraya to drive this transformation with the same clarity, dynamism and courage to speak truth to power.