UPSC MAINS

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SCIENCE & TECHNOLOGY

for Civil Servies Examination

Contents

INTRODUCTION

- Science and Technology are perceived as the major tools for rapid social and economic development. The more industrialized countries of the world applied science and technology to uplift their socio-economic conditions. China, South Korea, India, Malaysia and Singapore, and a few other countries, followed their footsteps and have also successfully applied science and technology to transform their society.
- Scientific thought and interest have been at the backbone of mankind's advancements and progress – be it the discovery of fire, the wheel or the power of nuclear fission. Scientific temperament and an inquisitive mind are essential for the people to move forward, as only a scientific mind can enquire into situations and seek solutions.
- Science, however, is not only about abstract thoughts but also about its application in various fields impacting the common man. Science of today is the technology of tomorrow. Development is always linked with technology. Particularly in today's knowledge based economies, science and technology are the basic pre requisites for development.
- Developments in science and technology are fundamentally altering the way people live, connect and communicate with each other. Scientific inventions like electricity, faster means of transport and weather forecasting systems have made life easier and better for the common man who has light at his disposal to study, travel faster for business and is pre-warned about disasters.
- Innovations in various sectors are helping young entrepreneurs to upgrade their skills and initiate start-ups. India, a food importer at one time, is now not only self-sufficient but is also able to export food items thanks to the Green Revolution. Scientific discoveries have helped farmers raise better crops at a faster pace, thus solving the problem of food shortage.
- Scientific breakthroughs have revolutionized healthcare by equipping medical practitioners with tools to gather information, make well informed decisions and treat critical diseases. From simple cataract operations to major heart transplants, advancements in medical technologies have contributed to improving quality of human life and increasing life expectancy.
- Technological advancements have taken education to the doorstep of students in far flung areas. On the one hand digitisation has enabled children in remote areas to access education material through internet, on the other hand invention of newer and interesting tools of teaching have made boring classes and writing on the blackboard a thing of the past. The world has indeed opened up and come closer to such children.
- Defence applications are also being adapted to societal development and civilian use. Bullet proof jackets, farming in high altitudes, multi insect repellents, food poison detection kits, etc are some of the outcomes of research and development in defence which are also being put to use in civilian sector.
- So far as space technology is concerned, India is considered as the leader in area of impacting day to day life through application programmes like tele-education and telemedicine.

- So is the case with nuclear technology. Hiroshima and Nagasaki had made atomic power one of the most dreaded words in the lexicon. But, thanks to our scientists, the power of the atom is now harnessed and used as nuclear energy for peaceful purposes. Health, agriculture, food preservation, energy are some of the areas hugely benefitted by nuclear innovations.
- Science and technology have proved to be a boon to human life. A nation which does not promote scientific thinking lags behind the race for development. Science for development is the slogan for the future.
- Science and Technology has been an integral part of Indian civilization and culture over the past several millennia. Few are aware that India was the fountainhead of important foundational scientific developments and approaches. These cover many great scientific discoveries and technological achievements in mathematics, astronomy, architecture, chemistry, metallurgy, medicine, natural philosophy and other areas. A great deal of this travelled outwards from India. Equally, India also assimilated scientific ideas and techniques from elsewhere, with open-mindedness and a rational attitude characteristic of a scientific ethos.
- India's commitment to the use of science and technology as a key instrument in national development has been clearly articulated time and again in various policy documents right from the early years of independence. Indeed, progress made by our country since the attainment of the stated goals in policy and plan documents has been substantial.
- In the pre-economic reform era, the question of scientific and technological development in India had a central role in the general debate on the country's development strategy, whether in policy-oriented discussions, in academic considerations or in discussions in the public and political arena.
- This eagerness to perform creatively in science came to be backed with an institutional setup and strong state support after the country's independence in 1947. Since then, the Government of India has spared no effort to establish a modern Science and Technology infrastructure in the country. The Government firmly believed that S&T would be the twin tools that would help bring about social equality and economic development to enable India join the mainstream of world community. This conviction was reflected in the Scientific Policy Resolution (SPR) of 1958, and subsequent Policies.

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INDIAN POLICY TOWARDS SCIENCE & TECHNOLOGY

- Science, Technology and Innovation (STI) are the key drivers for economic growth and human development. For India to march ahead on a sustainable development pathway to include economic development, social inclusion and environmental sustainability for achieving an "Atmanirbhar Bharat'', a greater emphasis will be given on promoting traditional knowledge system, developing indigenous technologies and encouraging grass root innovation.. The emergence of disruptive and impactful technologies poses new challenges and simultaneously greater opportunities.
- The COVID-19 pandemic provided a compelling opportunity for Research and Development (R&D) institutions, academia and industry to work in unison for sharing of purpose, synergy, collaboration and cooperation.

Science & Technology Policy 2013

- The Policy interalia aspires 'positioning India among the top five global scientific powers'. The policy goal is the establishment of a strong and viable **Science, Research and Innovation system for High Technology led path for India (SRISHTI).**
- **The Key Features of the STI Policy 2013 are:**
  - **Budget:** Increasing the Research and Development (R&D) spending to 2% in next five years' time through PPP; creating conductive environment for encouraging private sector investment in R&D.
  - **Manpower:** Promotion of spread of scientific temper amongst all sections of society; attracting talented and bright minds towards careers in science, research and innovation; increasing the number of R&D personnel by 66% in next five years; creating environment for women to enter in R&D field; and setting up inter university centers, bringing together different disciplines of humanities and science together.
  - **Business:** Identifying 10 sectors of high potential and putting more resources into them for STI; increasing by two folds the global share of high tech products; increasing R&D intensity in service sector, small and medium scale enterprises; sharing the risk on R&D investments with private sector; providing new financing mechanisms for entrepreneurs; creating a public procurement policy that favors indigenous innovations; achieving synergy between R&D policy for agriculture vs. STI policy.
  - **Climate Change**: Active role in implementation of National Action plan for Climate Change (NAPCC); and providing incentives for green manufacturing.
  - **PPP:** Setting up of a) a National science, Technology and innovation foundation to facilitate investments in S&T projects under PPP mode and large scale R&D facilities under PPP mode; establishing technology business incubators and science-led entrepreneurships; and treating private sector R&D institutions at par with public sector institutions for giving public funds.

- **IPR:** Modification of Intellectual Property Rights (IPR) for social goods and IPR generated under PPP; setting up of a regulatory and legal framework for sharing IPRs between Investors and inventors.
- **Participation:** Encouraging participation of all STI stakeholders including: a) women and differently-abled and disadvantaged sections of society; b) NGOs who would play pivotal role for delivery science-tech-innovation outputs especially related with rural / grassroots level; c) State Governments by setting up state specific plans and strengthening the State Sci-Tech Councils / Boards and fine-tuning five-year plan schemes in response to rapid changes in S&T; d) International partners by forging strategic alliances both bilateral and multilateral.
- **Public awareness:** Releasing white papers on new science projects to generate public awareness about the ethical / social / economic implications of science-tech-R&D initiatives.

- **Critical Analysis of Policy**
  - Unfortunately, the Policy adopts a 'one-size, fit-all' approach towards STI. Though the basic policy tools may remain the same across the board, customized policy tools may be required for each sector. For instance, the policy framework The Policy has also totally overlooked Traditional Knowledge ("**TK**") especially when the potential is untapped. There is ample scope for leveraging our TK for achieving the larger objectives of the Policy. The Policy fails to integrate the aforesaid aspect into its framework. It is to be noted that the Policy seeks to "*vertically integrate all dimensions of STI into the socio-economic processes"* and promote" *inclusive innovation"*. The Policy, further, states that the focus is on *"both people for science and science for people"*. Perceived in this context, its muted approach towards leveraging TK is perturbing. Further the good and bad of Indian policy initiatives for scientific research and innovation', several forthcoming initiatives of the government are stalled either at Parliament or in Ministry of S&T.
  - There exists regulatory deficit in Indian science which is a debilitating factor for any forthcoming wholesome and sustainable progress in STI. The Policy should have called for a quick review and implementation of the same as these delays dent the objectives stated to be achieved.
  - The Policy does not clearly put forward its approach vis-à-vis IPR. It also does not explore the linkage between traditional IP protection and innovation. The Policy states that it will modify *"IPR policy to provide for marching rights for social good when supported by public funds and for co-sharing IPRs generated under PPP."* It does not define the expression *"marching rights"*. Considering the context, it is likely to mean that where public funds are used, IPRs will be modified to direct the benefits of the innovation towards social good. I must note that the aforesaid objective is couched in abstract terms and the Policy does not set out or at least provide an outline for achieving the aforesaid objective. Further, the Policy merely puts forward mechanisms such as "Small Idea-Small Money" and "Risky Idea Fund" for supporting innovation incubators without elaborating upon them.
  - Further rather than focusing on enhancing the R&D facilities in universities (which should have received the primary focus), it intends to multiply inter-university centres *"to enable a wide cross section of university researchers to access advanced research facilities and equipment which are otherwise not available in university environments."*

Draft 5th Science, Technology and Innovation (STI) Policy

- The new Science, Technology, Innovation Policy aims to bring about profound changes through short-term, medium-term, and long-term mission mode projects by building a nurtured ecosystem that promotes research and innovation on the part of both individuals and organizations.
- It aims to foster, develop, and nurture a robust system for evidence and stakeholder-driven STI planning, information, evaluation, and policy research in India.
- The policy will identify and address strengths and weaknesses of the Indian STI ecosystem to catalyse socio-economic development of the country and also make the Indian STI ecosystem globally competitive.

Vision

The Science, Technology and Innovation Policy will be guided by the following broad vision;

- To achieve technological self-reliance and position India among the top three scientific superpowers in the decade to come.
- To attract, nurture, strengthen and retain critical human capital through a 'people centric' science, technology and innovation (STI) ecosystem.
- To double the number of Full-Time Equivalent (FTE) researchers, Gross Domestic Expenditure on R&D (GERD) and private sector contribution to the GERD every 5 years.
- To build individual and institutional excellence in STI with the aspiration to achieve the highest level of global recognitions and awards in the coming decade.

Summary

A broad summary of Science, Technology and Innovation Policy (STIP) is given as under:

- STIP will lead to the establishment of **a National STI Observatory** that will act as a central repository for all kinds of data related to and generated from the STI ecosystem. It will encompass an open centralised database platform for all financial schemes, programmes, grants and incentives existing in the ecosystem. The Observatory will be centrally coordinated and organized in distributed, networked and interoperable manner among relevant stakeholders.
- A **future-looking, all-encompassing Open Science Framework** will be built to provide access to scientific data, information, knowledge, and resources to everyone in the country and all who are engaging with the Indian STI ecosystem on an equal partnership basis. All data used in and generated from publicly-funded research will be available to everyone under FAIR (findable, accessible, interoperable and reusable) terms. A dedicated portal to provide access to the outputs of such publicly-funded research will be created through Indian Science and Technology Archive of Research (INDSTA). Additionally, full text of final accepted author versions of manuscripts (post-prints and optionally pre-prints) supported through public funding will be deposited to an institutional or central repository. The policy will create pathways for the Government to negotiate with journal publishers for a "**one nation, one subscription" policy** whereby, in return for one centrally-negotiated payment, all individuals in India will have access to journal articles.
- **Strategies to improve STI education making it inclusive at all levels** and more connected with the economy and society will be developed through processes of skill building, training and infrastructure development. Engaged Universities will be created to promote interdisciplinary research to address community needs. **Higher Education Research Centres** (HERC) and **Collaborative Research Centres** (CRC) will be established to provide research inputs to policymakers and bring together stakeholders. Online learning platforms will be developed using Information and Communication Technology (ICT) to address the issue of accessibility and to promote research and innovation at all levels. Teaching-learning centres (TLCs) will be established to upskill faculty members which in turn will improve the quality of education.
- With an aim **to expand the financial landscape of the STI ecosystem**, each department/ ministry in the central, the state and the local governments, public sector enterprises, private sector companies and startups will set up an STI unit with a minimum earmarked budget to pursue STI activities. Extramural funding will be diversified and enhanced to double the share of extramural R&D support of the Central government agencies in the Gross Domestic Expenditure on R&D (GERD) in the next five years. Each State will earmark a percentage of the state allocation for STI-related activities under a separate budget head. Foreign Multi-National Companies (MNCs) will collaborate with domestic private and public sector entities on projects aligned to national needs and priorities. STI investments will be increased through boosting fiscal incentives, enhancing support to industry, especially Medium Small Micro Enterprises (MSMEs), for pursuing research through innovation support schemes and other relevant means on a need basis. Hybrid funding models with enhanced participation from public and private sectors will be created through the Advanced Missions in Innovative Research Ecosystem (ADMIRE) initiative. To ensure systematic governance of the expanded STI financing landscape, an STI Development Bank will be set up to facilitate a corpus fund for investing in direct long term investments in select strategic areas on various long and medium-term projects, commercial ventures, start-ups, technology diffusion and licensing etc.
- The policy aims to create a fit for **purpose, accountable research ecosystem promoting translational as well as foundational research in India in alignment with global standards**. Research and Innovation Excellence Frameworks (RIEF) will be developed to enhance the quality of research along with promotion of engagements with relevant stakeholders. Proper guidelines will be formulated to enhance the operating and safety protocols related to R&D. Research culture will be reoriented to recognize social impacts along with academic achievements.

- The policy envisions strengthening of the overall innovative ecosystem, fostering Science & Technology (S&T) - enabled entrepreneurship, and improving participation of the grassroots levels in the research and innovation ecosystem. An institutional architecture to integrate **Traditional Knowledge Systems (TKS) and grassroots innovation** into the overall education, research and innovation system will be established. Collaborations between grassroots innovators and scientists will be facilitated through joint research projects, fellowships and scholarships. Grassroots innovators will also be supported for registration, claiming the Intellectual Property Right (IPR), filing of patent, or any type of legal claim with the help of Higher Education Institute (HEIs). Advanced tools based on Artificial Intelligence (AI) and machine learning will be used for curation, preservation and maintenance of heritage knowledge.
- The policy will promote **technology self-reliance and indigenization** to achieve the larger goal of "**Atmanirbhar Bharat**". A two-way approach of indigenous development of technology as well as technology indigenization will be adopted and focused upon in alignment with national priorities, like sustainability and social benefit, and resources. International engagements will be facilitated to gain essential know-how towards creation and development of indigenous technologies. A Technology Support Framework will be created to facilitate this development. A Strategic Technology Board (STB) will be constituted to act as a link connecting different strategic departments. A Strategic Technology Development Fund (STDF) will be created to incentivize the private sector and HEIs. Spin-off technologies resulting from the larger projects will be commercialized and used for civilian purposes.
- The policy provides renewed impetus to the mainstreaming of **equity and inclusion** within the STI ecosystem. An inclusive culture will be facilitated through equal opportunity for women along with candidates from rural remote areas, marginalised communities, differently-abled individuals including Divyangjans, irrespective of their socio-economic backgrounds, proportionate representation of women in selection/ evaluation committees, addressing of ageism related issues and consideration of experienced women scientists for leadership roles and regular gender and social audits in academic and professional organizations. The Lesbian, Gay, Bisexual, Transgender, Queer (LGBTQ+) community will be included in gender equity conversations with special provisions to safeguard their rights and promote their representation and retention in STI.
- The policy will work towards **mainstreaming science communication and public engagement** through the development of capacity building avenues through creative and cross-disciplinary platforms, research initiatives, and outreach platforms. Locally relevant and culturally-context-specific models will be developed along with promoting cross disciplinary research in Science Communication. To improve Science teaching, the engagements between science communication and science pedagogy will be facilitated. Entertainment platforms such as television (TV), community radio, comics etc. will be explored to take science to the last mile. Non-governmental Organizations (NGOs) and Civil Society groups will be involved through popular science programmes and citizen science projects at local and regional levels. Science Media Centres will be established at national and regional levels to connect scientists with media persons and science communicators.
- STIP charts pathways to a **dynamic, evidence-informed and proactive international S&T engagement** strategy. Engagement with the Diaspora will be intensified through attracting the best talent back home through fellowships, internships schemes and research opportunities expanded and widely promoted across different ministries. Appropriate facilitating channels will be created for remote contribution as well. An engagement portal exclusively for the Indian scientific diaspora will be created. '**S&T for Diplomacy**' will be complemented with Diplomacy for S&T '. International Knowledge Centres, preferably virtual, will be established to promote global knowledge and talent exchange. The number of S&T Counsellors will be increased with redefinition and revitalisation of their roles.
- A **decentralized institutional mechanism** balancing top-down and bottom-up approaches, focussing on administrative and financial management, research governance, data and regulatory frameworks and system interconnectedness, will be formulated for a robust STI Governance. Appropriate mechanisms will be set up at the highest levels for the overall (including inter-sectoral, inter-ministerial, Centre-State and inter-State) governance of the STI ecosystem. A robust Research and Innovation (R&I) governance framework will be set up to facilitate, stimulate and coordinate R&D activities across the sectors. A Capacity Building Authority will be set up to help plan, design, implement and monitor capacity building programmes at the national and state level. A strong STI collaboration framework to strengthen existing channels and create new ones for enhanced interconnectedness among all relevant stakeholders at the domestic and global levels will be created, promoting inter-institutional, inter-ministerial, interdepartmental and cross-sectoral vertical and horizontal linkages and multi-stakeholder partnerships, to pursue projects in alignment with the national priorities.

- The policy outlines the institutional mechanism for **STI policy governance along with the implementation strategy and roadmap and monitoring and evaluation framework for the policy and programs** and their inter-linkages. To serve all the aspects of STI policy governance and to provide the knowledge support to institutionalised governance mechanisms, a STI Policy Institute will be established to build and maintain a robust interoperable STI metadata architecture. It will conduct and promote nationally and internationally relevant STI policy research and strengthen the science advice mechanism at national, sub-national and international levels. It will develop long term capacity building programs for STI policy through training and fellowships. An implementation strategy and roadmap will be devised for STI policy and programs along with continuous monitoring and timely evaluation mechanisms.

Conclusion

To capture the aspirations of a new, future-ready India, by ensuring active participation, shared responsibility and equitable ownership of all stakeholders; transforming the national STI landscape maintaining the delicate balance between fortifying India's indigenous capacity and nurturing meaningful global interconnectedness.

Institutional Structure

Department of Science & Technology

- Department of Science & Technology (DST) was established in May 1971, with the objective of promoting new areas of Science & Technology and to play the role of a nodal department for organizing, coordinating and promoting S&T activities in the country. The Department has major responsibilities for specific projects and programmes as listed below:
  - Formulation of policies relating to Science and Technology.
  - Matters relating to the Scientific Advisory Committee of the Cabinet (SACC).
  - Promotion of new areas of Science and Technology with special emphasis on emerging areas.
  - Futurology.
  - Coordination and integration of areas of Science & Technology having cross-sectoral linkages in which a number of institutions and departments have interest and capabilities.
  - Undertaking or financially sponsoring scientific and technological surveys, research design and development, where necessary.
  - Support and Grants-in-aid to Scientific Research Institutions, Scientific Associations and Bodies.
  - All matters concerning:
    - Science and Engineering Research Council;
    - Technology Development Board and related Acts
    - National Council for Science and Technology Communication;
    - National Science and Technology Entrepreneurship Development Board;
    - International Science and Technology Cooperation
    - Autonomous Institutions relating to the subject under the Department of Science and Technology including Institute of Astro-physics, and Institute of Geo-magnetism;
    - Professional Science Academies funded by Department of Science and Technology;
    - The Survey of India, and National Atlas and Thematic Mapping Organization;
    - National Spatial Data Infrastructure and promotion of G.I.S;
    - The National Innovation Foundation, Ahmadabad.
  - Matters commonly affecting Scientific and technological departments/organizations/ institutions e.g. financial, personnel, purchase and import policies and practices.
  - Management Information Systems for Science and Technology and coordination thereof.

- Matters regarding Inter-Agency/Inter-Departmental coordination for evolving science and technology missions.
- Matters concerning domestic technology particularly the promotion of ventures involving the commercialization of such technology other than those under the Department of Scientific and Industrial Research.
- All other measures needed for the promotion of science and technology and their application to the development and security of the nation.
- Matters relating to institutional Science and Technology capacity building including setting up of new institutions and institutional infrastructure.
- Promotion of Science and Technology at the State, District, and Village levels for grass- roots development through State Science and Technology Councils and other mechanisms.
- Application of Science and Technology for weaker sections, women and other disadvantaged sections of Society.

Council of Scientific and Industrial Research (CSIR)

- The CSIR was established in 1942 as an autonomous, non-profit organization with a wide ranging charter of functions.

  CSIR functions:

  - Promotion, guidance and co-ordination of scientific and industrial research
  - Collection and dissemination of information on research and industry
  - Founding of laboratories to carry forward scientific and industrial research
  - Utilization of the new knowledge for development of industry
  - Rendering assistance to other institutions conducting research, awarding of fellowships and publishing of scientific journals.

  CSIR achievements:

  - The induction of precocious flowering in plantlets of bamboo raised in tissue culture;
  - Discovery of one of the smallest protein molecules, seminal plasmin;
  - The first combined genetic and physical map of the whole *V. cholerae* genome;
  - The elucidation of the mechanisms for delaying the formation of cataract in the human eye;
  - To introduce buffalo milk for baby food (brand name 'Amul');
  - It launched the wholly indigenous tractor *Swaraj*;
  - Developed a cost-effective process for drugs for mass use;
  - It was the first to extract polymetallic nodules from the Indian ocean bed, based on which India became the first country in the world to be granted 'pioneer status', under the UN treaty on the Laws of Seas;
  - Development of Aerospace materials such as high-density carbon-carbon composites, Nalar—a Kevlar equivalent high strength fibre, aluminium-lithium alloys, high purity aluminium;
  - Development of Industrial materials for special performance such as silicon carbide, silicon nitride bonded silicon carbide, silicon carbide whiskers, aluminium metal matrix and aluminium-graphite composites, special glasses for optical fibres, infrared range finders, laser glasses, radiation shielding glasses and sol-gel techniques for glass coatings etc.

Survey of India (SOI)

- The national survey and mapping organisation under the Ministry of Science and Technology, was set up in 1767. Its assigned role is that of **National Principal Mapping Agency**.
- Survey of India bears a special responsibility to ensure that the country's domain is explored and mapped suitably to provide base maps for expeditious and integrated development and ensure that all resources contribute their full measure to the progress, prosperity and security of India.

- The primary responsibility of SOI is to maintain topographical map coverage on 1:250K, 1:50K and l:25K scales.
- Survey Training Institute, Hyderabad established under UNDP assistance is a premier institution for training in various disciplines of surveying and mapping to the trainees sponsored by the Department, other state/ central government organisations and neighbouring countries.

National Atlas and Thematic Mapping Organisation (NATMO)

- Operating under the DST, it concentrates its attention in a number of areas to integrate resource maps with other relevant socio-economic data and represent them in spatial forms, useful for developmental planning.
- NATMO is trying to develop the technology of reverse printing for NATMO maps on experimental basis.
- It is also trying to introduce the technique of using metallic colours in map printing. These facilities are also being modernized.

Science and Engineering Research Council

- The **Science and Engineering Research Council (SERC)** was established in 1974 and is an apex body through which the **Department of Science and Technology (DST),** Govt. of India promotes R&D programmes in newly emerging and challenging areas of science and engineering. SERC is composed of eminent scientists, technologists drawn from various universities/national laboratories and Industry.

Technology Development Board

- The Technology Development Board was constituted in September 1996. The Board provides financial assistance to industrial concerns and other agencies for attempting development and commercial application of indigenous technology or adapting imported technology for wider domestic application. The areas that got financial assistance from the Board were health and medicine, engineering and electronics, chemicals and lubricants, agriculture and biotechnology, information technology, road/air transport, energy and waste utilization, and telecommunication.

National Accreditation Board For Testing And Calibration Laboratories

- The **National Accreditation Board for Testing and Calibration Laboratories (NABL)** provides formal recognition for technical competence of testing, calibration and medical laboratories. NABL accreditation is primarily based on ISO/IEC 17025:2005 for testing and calibration laboratories and ISO 15189:2003 for medical laboratories.

Science and Engineering Research Board

- The Science and Engineering Research Board (SERB) is a statutory body established through an Act of Parliament. Supporting basic research in emerging areas of Science & Engineering are the primary and distinctive mandate of the Board. The Board structure, with both financial and administrative powers vested in the Board, would enable quicker decisions on research issues, greatly improving thereby our responsiveness to the genuine needs of the research scientists and the S&T system.
- SERB supports research in frontier areas of Science and Engineering. A regular faculty / researcher in an academic / research institution can seek research support to carry out his/her research. Board also gives special attention to young scientists below the age of 35 years (relaxable by 5 years in the case of SC/ST/ OBC, woman and physically handicapped category) to undertake independent research in newly emerging and frontier areas of science and engineering.
- High priority areas are supported in through the "Intensification of Research in High Priority Area "(IRHPA) Program. The Board offers JC Bose National Fellowship to scientists and engineers for their outstanding performance and contributions and RAMANUJAN Fellowship for brilliant scientists and engineers from all over the world to take up scientific research positions in India, especially those scientists who want to return to India from abroad. Board also provides financial assistance for presenting research paper in international scientific event (conference/ seminar/ symposium/ workshop etc.) held abroad.
- SERB extends partial financial support, on selective basis, for organising scientific events (National as well as International) in the country.

Scientific & Engineering Research

VAJRA

- Launched during the 14th Pravasi Bharatiya Divas Convention at Bengaluru on 8th January 2017, the VAJRA (Visiting Advanced Joint Research) Faculty scheme by the Department of Science and Technology enables NRIs and overseas scientific community to participate and contribute to research and development in India.
- The Science and Engineering Research Board (SERB), a statutory body of the Department will implement the Scheme.
- VAJRA faculty will undertake research in S&T priority areas of nation wherein the capability and capacity are needed to be developed. The VAJRA faculty will engage in collaborative research in public funded institutions.
- The residency period of the VAJRA Faculty in India would be for a minimum of 1 month and a maximum of 3 months a year.
- The VAJRA Faculty is provided a lump-sum amount of US$ 15000 in the first month of residency in a year and US$ 10000 p.m. in the other two months to cover their travel and honorarium. While no separate support is provided for e.g. accommodation, medical / personal insurance etc. the host institute may consider providing additional support.
- The Indian collaborator and the overseas faculty will jointly frame a research plan and the application duly endorsed by the Head of the Institution will be submitted online by the Indian collaborator.
- A Selection Committee of eminent scientists will evaluate the applications. The Committee will meet twice a year in January and July and make recommendations. SERB will announce the results in the month of April and September.
- Public funded academic institutions and national laboratories are eligible to host the VAJRA Faculty. These institutions should appoint them as Adjunct / Visiting Faculty and involve them in co-guiding and mentoring of students and developing collaborative programs. The Faculty can also be allowed to participate in other academic activities as agreed to by the host institution and the Faculty.

Cognitive Science Research Initiative (CSRI)

- Cognitive Science is the study of human mind and brain, focusing on how mind represents and manipulates knowledge and how mental representations and processes are realized in the brain. The field is highly trans disciplinary in nature, combining ideas, principles and methods of psychology, computer science, linguistics, philosophy, neuroscience etc.
- With this aim, the Department of Science & Technology (DST) had initiated a highly focused programme "Cognitive Science Research Initiative (CSRI)" in 2008 during 11th Five year plan.
- The Cognitive Science Research Initiative facilitates a platform to scientific community to work for better solution of challenges related with cognitive disorders and social issues through various psychological tools & batteries, early diagnosis & better therapies, intervention technologies and rehabilitation programmes.

National Science & Technology Management Information System

- NSTMIS, DST is responsible for collection, collation, analysis and dissemination of information on resources devoted to S&T activities in the country.
- The Scientific and Technological (S&T) activities play a vital role in the economic, social and physical development of a country. Scientific and technological research needs huge investments and calls for a judicious utilization of scarce resources like finance, trained manpower, raw materials etc.
- Data collection and analysis pertaining to resources, devoted to S&T, therefore, assumes significant importance. The growth of S&T, its performance and impact on society and economy are indicators to assess the effectiveness of planning and policy formulation.

- The National Science and Technology Management Information System (NSTMIS), a division of Department of Science and Technology (DST) has been entrusted with the task of building the information base on a continuous basis on resources devoted to scientific and technological activities for policy planning in the country.

Science and Technology of Yoga and Meditation (SATYAM)

- Department of Science and Technology (DST), in 2015, conceptualized a new research program- 'Science and Technology of Yoga and Meditation' (SATYAM) - under its Cognitive Science Research Initiative (CSRI).
- As Yoga and Meditation are interdisciplinary endeavors that interface with Neuroscience, Medicine, Psychology, Philosophy, and so on, therefore an interdisciplinary approach is needed to converge different & diverse disciplines as well as approaches & methods in the study of yoga and meditation. Thus comprehensive research on yoga and meditation is expected to address various challenges confronting physical and mental health. This new programme is aimed to foster scientific research on the effects of yoga and meditation on physical & mental health and on cognitive functioning in healthy people as well as in patients with disorders.
- Basic themes being covered under SATYAM include, among others, (1) investigations on the effect of Yoga and Meditation on physical and mental health and well-being, and (2) investigations on the effect of Yoga and Meditation on the body, brain, and mind in terms of basic processes and mechanisms.
- Scientists/academicians with research background in 'Yoga and Meditation' and having regular position are invited to participate in this initiative. Practitioners actively involved in yoga and meditation practices are also encouraged to apply in collaboration with academic and research institutions of repute. Interested researchers are required to submit research proposals in their area of expertise along with Endorsement Certificate from the Head of the Institution and detailed bio-data of PI and Co-PIs.

R&D Infrastructure

- The R&D Infrastructure Division of the DST aims to strengthen the S&T infrastructure of the country by fostering well-equipped R&D labs in the academic/ research institutes/ universities as well as a strong culture of research collaboration between institutions and across disciplines.
- It has four schemes the objectives of which, at large, are establishment of R&D labs, centres, upgradation of research facilities orienting towards creating a self- reliant India.

FIST (Fund for Improvement of S&T Infrastructure in Universities and Higher Educational Institutions)

- This scheme is operated in competitive mode of support at four levels. The financial support circumscribes six basic purposes i.e. Equipment, Infrastructural Facilities, Networking & Computational Facilities, Industrial R&D Support, SSR Activities and Maintenance.
- Depending on the level, the total financial support is limited to Rs. 1.50 Crore (Level 0), Rs. 3.0 Crore (Level 1), Rs.5.0 Crore (Level 2) and Rs.10.0 Crore (Level 3).
- The program prefers to focus towards supporting interdisciplinary problems, solution-centric and translational research, and increasing the scope for participation of industries and start-ups and new ideas, aiming towards Aatma Nirbhar Bharat' as well as cater to the needs and aspirations of the society (SSR).

PURSE (Promotion of University Research and Scientific Excellence)

- The main objective of the scheme is to strengthen the research capacity of performing Indian Universities and provide support for nurturing the research ecosystem and strengthening the R&D base of the Universities in the country.
- Department of Science & Technology has restructured and re-oriented PURSE in the year 2020. A combination of i10-index of faculty members in the University, H-index of the University along with NIRF Ranking is used to formulate the new criteria for selection of Universities under PURSE.

SAIF (Sophisticated Analytical Instrument Facilities)

- The SAIF scheme is being implemented regionally with the objective to provide facilities of sophisticated analytical instruments to the research workers in general and especially from the institutions which do not have such instruments to enable them to pursue R&D activities.

- This enables the institutions acquiring such facilities to keep pace with development taking place globally.

SATHI (Sophisticated Analytical & Technical Help Institutes)

- This scheme initiates the setting up of shared, professionally managed Science &Technology Infrastructure facility readily accessible to academia, start-ups, manufacturing units, industries and R&D Labs.
- SATHI Centres will be equipped with major analytical instrument and advanced manufacturing facility, which is usually not available at Institutes/ Organisations.
- The aim is to provide professionally managed services with efficiency, accessibility and transparency of highest order under one roof to service the demands of industry, start-ups and academia.

STUTI (Synergistic Training program Utilizing the Scientific and Technological Infrastructure)

- The program has been designed to cater to human resource and its capacity building through open access to S&T Infrastructure across the country by organizing short term courses/ workshops on the awareness, use and application of various instruments and analytical techniques.

Interdisciplinary Cyber Physical Systems (ICPS)

- DST has recently launched a new programme "Interdisciplinary Cyber Physical Systems (ICPS)" to foster and promote R&D in this emerging field of research.
- A Cyber Physical System (CPS) is a mechanism controlled or monitored by computer-based algorithms, tightly integrated with internet and its users. It is an engineered system that are built from and depend upon, the seamless integration of computational algorithms and physical components. In general Cyber means computation, communication and control that are discrete and logical.
- Physical means natural and human-made systems governed by the laws of physics and operating in continuous time. Computing and communication systems bridges with the physical world are referred to as Cyber Physical Systems.
- CPS are physical and engineered systems whose operations are monitored, coordinated, controlled and integrated by a computing and communication core.

Women Scientists Programs

Gender Advancement for Transforming Institutions (GATI)

- Women in India face several challenges in moving up the academic and administrative ladder due to systemic barriers and structural factors. Gender equality in scientific laboratories and institutions of higher education is not only about numbers but also about various micro and macro level factors operating at institutional level. There exist various policies and enabling environment in different institutions in India but a common approach or guiding principles to bridge the gender gap is still lacking. In science and technology sector it is difficult to assess and evaluate the merit of existing process/procedures from gender lens. This clearly demonstrates a need for multi stakeholder interventions. While gender equality in science is an important consideration, it is also in the larger interest of scientific progress and society.
- Considering the need of gender advancement in STEMM area at institutional level, the GATI program is now launched by the Department of Science and Technology (DST).
- DST is inviting Expression of Interest to participate in the pilot of GATI. Universities, and other S&T Institutions are invited to participate in pilot of Gender Advancement for Transforming Institutions (GATI) launched by Government of India. GATI is a novel pilot programme envisioned in mission mode to promote gender equity in Science, Technology, Engineering, Mathematics and Medicine (STEMM) domains.

Women Scientists Scheme

- Women are an important section of the workforce, more particularly in the science & technology (S&T) domain. However, a large number of well-qualified women get left out of the S&T activities due to various circumstances which are usually typical to the gender. The challenges faced by them are several but most

often the "break in career" arises out of motherhood and family responsibilities. To address such issues, Department of Science and Technology (DST) launched "Women Scientists Scheme (WOS)" during 2002-03. This initiative primarily aimed at providing opportunities to women scientists and technologists between the age group of 27-57 years who had a break in their career but desired to return to mainstream.

- Through this endeavour of the Department, concerted efforts have been made to give women a strong foothold into the scientific profession, help them re-enter into the mainstream and provide a launch pad for further forays into the field of science and technology.

New Initiatives Aligned with the National Agenda

NSM

- The Mission envisages empowering our national academic and R&D institutions spread over the country by installing a vast supercomputing grid comprising of more than 70 high-performance computing facilities. These supercomputers will also be networked on the National Supercomputing grid over the National Knowledge Network (NKN).
- The NKN is another programme of the government which connects academic institutions and R&D labs over a high speed network. Academic and R&D institutions as well as key user departments/ministries would participate by using these facilities and develop applications of national relevance.
- The Mission also includes development of highly professional High Performance Computing (HPC) aware human resource for meeting challenges of development of these applications.
- The Mission implementation would bring supercomputing within the reach of the large Scientific & Technology community in the country and enable the country with a capacity of solving multi-disciplinary grand challenge problems.
- The Mission would be implemented and steered jointly by the Department of Science and Technology (DST) and Department of Electronics and Information Technology (DeitY) at an estimated cost of Rs.4500 crore over a period of seven years.

Objective

- To make India one of the world leaders in Supercomputing and to enhance India's capability in solving grand challenge problems of national and global relevance
- To empower our scientists and researchers with state-of-the-art supercomputing facilities and enable them to carry out cutting-edge research in their respective domains
- To minimize redundancies and duplication of efforts, and optimize investments in supercomputing
- To attain global competitiveness and ensure self-reliance in the strategic area of supercomputing technology

Application areas

- Climate Modelling
- Weather Prediction
- Aerospace Engineering including CFD, CSM, CEM
- Computational Biology
- Molecular Dynamics
- Atomic Energy Simulations
- National Security/ Defence Applications
- Seismic Analysis
- Disaster Simulations and Management

- Computational Chemistry
- Computational Material Science and Nanomaterials
- Discoveries beyond Earth (Astrophysics)
- Large Complex Systems Simulations and Cyber Physical Systems
- Big Data Analytics
- Finance
- Information repositories/ Government Information Systems

Nano Science and Technology

- National Mission of Nano Science and Technology - an umbrella programme was launched in 2007 to promote R&D in this emerging area of research in a comprehensive fashion.
- **The main objectives of the Nano Mission are:**
  - Basic research promotion,
  - Research infrastructure development,
  - Nano application and technology development,
  - Human resource development,
  - International collaboration and orchestrating national dialogues.
- India has secured third position amongst nations of the world in terms of scientific publications in this emerging area.

Climate Change

- National Mission for Sustaining the Himalayan Ecosystem (NMSHE) and National Mission for Strategic Knowledge on Climate Change (NMSKCC) launched under National Action Plan for Climate Change (NAPCC) are under implementation by the Department.
- Himalayas Climate Change Portal has been launched to make the knowledge on Himalayas readily available for the end users and community.

Other initiatives

- National Initiative for Developing and Harnessing Innovations (**NIDHI**) has been evolved as an umbrella scheme for a seamless innovation ecosystem booster.

  The specific components of NIDHI are:

  - Promotion and Acceleration of Young and Aspiring innovators & Startups (**PRAYAS**) - Support from Idea to Prototype;
  - Entrepreneur in Residence (**EIR**) - Support system to reduce risk;
  - Startup-NIDHI through Innovation and Entrepreneurship Development Centres (IEDCs) in academic institutions for encouraging students to promote start-ups; and
  - Start-up Centre in collaboration with MHRD— inculcating a spirit of entrepreneurship in National Institutions of Higher Learning.
    - **MANAK** (Million Minds Augmenting National Aspirations and Knowledge): To widen the base of the innovation pyramid by cultural intervention, ideas relevant to the national needs are to be invited from 10 lakh school students in any language.
    - With the objective to contribute towards **Swachh Bharat**, a new programme viz. **Technology Development for Waste Management** has been initiated to come up with technological solutions for the problems faced by the country in waste management.

Mega Science Projects & Facilities

Open Source Drug Discovery (OSDD)

- Open Source Drug Discovery (OSDD) is a CSIR led team India Consortium with global partnership with a vision to provide affordable healthcare to the developing world by providing a global platform where the best minds can collaborate & collectively endeavor to solve the complex problems associated with discovering novel therapies for neglected tropical diseases like Tuberculosis, Malaria, Leishmaniasis etc. OSDD has more than 5975 registered partners from more than 130 countries around the world.
- OSDD is currently focused on the discovery of novel drugs for TB and Malaria. OSDD collaboratively aggregates the biological, genetic and chemical information available to scientists in order to use it to hasten the discovery of drugs. This will provide a unique opportunity for scientists, doctors, technocrats, students and others with diverse expertise to work for a common cause.
- OSDD is a translational platform for drug discovery, bringing together informaticians, wet lab scientists, contract research organizations, clinicians, hospitals and others who are willing to adhere to the affordable healthcare philosophy agreeing to the OSDD license.

Large Hadron Collider (LHC)

- The Large Hadron Collider (LHC) is the world's largest and most powerful particle accelerator. It consists of a 27-kilometer ring of superconducting magnets with a number of accelerating structures to boost the energy of the particles along the way.
- Indian scientists have been involved in the design of many components of the LHC, whereas construction of those took place by scientists and engineers through Indian industries. Some of these components include superconducting corrector magnets, precision magnetic positioning system jacks, accelerator protection systems, quench detection electronics, vacuum system design for long beam transport lines, and cryogenic systems.

Square Kilometre Array (SKA)

- The Square Kilometre Array (SKA) project is an international effort to build the world's largest radio telescope, with eventually over a square kilometre (one million square metres) of collecting area. The scale of the SKA represents a huge leap forward in both engineering and research & development towards building and delivering a unique instrument, with the detailed design and preparation now well under way. As one of the largest scientific endeavours in history, the SKA will bring together a wealth of the world's finest scientists, engineers and policy makers to bring the project to fruition.
- In the first phase there will be about 200 dishes in South Africa's Karoo region, and over 130,000 low frequency antennas in Western Australia's Murchison Shire, that will monitor the sky in unprecedented detail, in a complementary range of radio frequencies. The two sites are chosen for co-hosting the SKA based on the characteristics of the atmosphere above the sites and their radio quietness, which comes from being some of the most remote yet accessible locations on the Earth. The unprecedented sensitivity of the SKA's receivers will allow insights into the formation and evolution of the first stars and galaxies after the Big Bang, the role of cosmic magnetism, the nature of gravity, and possibly even life beyond Earth, not to mention serendipitous discoveries that are expected when something so much more sensitive than any existing facility is built. Indian scientists are involved in many of the SKA's Science Working Groups, and India co-chairs the Solar Physics WG.
- Organisations from 14 countries are members of the SKA Organisation – Australia, Canada, China, France, Germany, India, Italy, New Zealand, Spain, South Africa, Sweden, Switzerland, The Netherlands and the United Kingdom.

A Large Ion Collider Experiment (ALICE)

- The ALICE Collaboration has built a detector optimized to study the collisions of nuclei at the ultra-relativistic energies provided by the LHC. The aim is to study the physics of strongly interacting matter at the highest

energy densities reached so far in the laboratory. In such conditions, an extreme phase of matter - called the quark-gluon plasma - is formed.

- Indian scientists have played a significant role in the ALICE experiment, which is a dedicated experiment for search and study of Quark Gluon Plasma (QGP). Hardware contributions to the ALICE detector include the Photon Multiplicity Detector (PMD), the Muon Spectrometer, the MANAS chip, and Silicon pad detectors.
- The PMD is a fully Indian effort from conception to commissioning. The QGP research program of ALICE is on the quest to get a glimpse of how matter behaved within a few microseconds after the birth of our Universe. Indian scientists have contributed to the physics analysis, which led to the discovery of the QGP matter and its characterization.

Facility for Antiproton and Ion Research (FAIR)

- FAIR is an international accelerator facility at Darmstadt, Germany which will deliver beams for research in nuclear physics, hadron physics, high energy heavy ion collisions, atomic and plasma physics.
- India is a Founder-Member country for this project. As part of India's in-kind contributions, India has to supply sophisticated items like power converters, vacuum chambers, beam stoppers, superconducting magnets and advanced detector systems. Indian scientists and engineers from different R&D labs and industries are engaged in designing, developing, prototyping and supply of these items having stringent technical specifications as per international standards.

Thirty Metre Telescope (TMT)

- Telescopes built till today have led to many fascinating and intriguing discoveries in astronomy, like the discovery of planets around other stars, evidence of accelerating expansion of the universe, existence of dark matter and dark energy, monitoring of asteroids/comets that could pose a serious threat to the inhabitants of the Earth.
- To maintain this exciting pace of discovery, astronomers and engineers are pushing the boundaries of today's technology while simultaneously creating the innovations that will make the upcoming Thirty Meter Telescope (TMT) one of the world's most advanced and capable ground-based optical and infrared observatory.
- TMT is an international project which aims at building a 30-metre diameter telescope at Mauna Kea, Hawaii, USA at an estimated cost of 1.47 billion USD (Base year 2012 USD) involving an international consortium of scientific organizations and institutions in Canada, China, India, Japan and USA.
- India is a Founder-Member country for this project at about 10% level. India's in-kind contributions towards the project include Hardware (Segment Support Assemblies, Actuators, Edge Sensors, Segment Polishing and Segment Coating), Instrumentation (First Light Instruments) and Software (Observatory Software and Telescope Control Systems).

International Thermonuclear Experimental Reactor (ITER)

- ITER, "the way" is one of the largest experimental efforts underway in the south of France at Cadarache with an aim to demonstrate nuclear fusion as a clean green source of unlimited energy.
- India's contribution to ITER includes delivery of 9 in-kind packages to ITER. Each of the package to be delivered involves first of its kind development of materials, machining, technology and quality to meet with the stringent nuclear safety norms of the French regulatory board and also ensure that the components work for the life time of ITER.
- ITER work on the "Tokamak" concept where the reaction of hydrogen isotopes Deuterium and Tritium produces energy by the mass-energy conversion principle, thereby proving to be a source of unlimited energy.
- ITER partners are the European Union, China, India, Japan, South Korea, Russia and the United States of America. European Union being the host party contributes 45% while the rest of the parties contribute 9% each.

India-based Neutrino Observatory (INO)

- The India-based Neutrino Observatory (INO) Project is a multi-institutional effort aimed at building a world-class underground laboratory with a rock cover of approx. 1200 m for non-accelerator based high energy and nuclear physics research in India.
- Neutrino detectors around the world seem to see evidence that these weakly interacting, little-understood particles are not really massless, as was thought so far. Not only do they have non-zero masses, different species (or flavours) of neutrinos seem to mix and oscillate into one another as they traverse through the cosmos.
- If this is true, this is not only one of the first pieces of evidence for physics beyond the so-called Standard Model of Particle Physics but would also have great impact on diverse fields such as nuclear and particle physics, astrophysics and cosmology. It is thus imperative to study the details of the interactions of these particles. The best option of course is to have a lab in order to do so. In order to maximize the sensitivity to the interactions of these weakly interacting particles, such a neutrino lab is necessarily placed underground.

Laser Interferometer Gravitational-Wave Observatory (LIGO)

- The Laser Interferometer Gravitational-Wave Observatory (LIGO) was designed to open the field of gravitational-wave astrophysics through the direct detection of gravitational waves predicted by Einstein's General Theory of Relativity.
- LIGO's multi-kilometer-scale gravitational wave detectors use 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 by supernovae.
- LIGO - India is a planned advanced gravitational-wave observatory to be located in India as part of the worldwide network, whose concept proposal is now under active consideration in India and the USA. LIGO-India is envisaged as a collaborative project between a consortium of Indian research institutions and the LIGO Laboratory in USA, along with its international partners.

AstroSat

- AstroSat is the first dedicated Indian astronomy mission aimed at studying celestial sources in X-ray, optical and UV spectral bands simultaneously. The payloads cover the energy bands of Ultraviolet (Near and Far), limited optical and X-ray regime (0.3 keV to 100keV). One of the unique features of AstroSat mission is that it enables the simultaneous multi-wavelength observations of various astronomical objects with a single satellite.
- AstroSat with a lift-off mass of 1515 kg was launched on September 28, 2015 into a 650 km orbit inclined at an angle of 6 deg to the equator by PSLV-C30 from Satish Dhawan Space Centre, Sriharikota. The minimum useful life of the AstroSat mission is expected to be 5 years. After injection into Orbit, the two solar panels of AstroSat were automatically deployed in quick succession.
- The spacecraft control centre at Mission Operations Complex (MOX) of ISRO Telemetry, Tracking and Command Network (ISTRAC), Bengaluru manages the satellite during its entire mission life. The science data gathered by five payloads of AstroSat are telemetered to the ground station at MOX. The data is then processed, archived and distributed by Indian Space Science Data Centre (ISSDC) located at Bylalu, near Bengaluru.
- The scientific objectives of AstroSat mission are:
  - To understand high energy processes in binary star systems containing neutron stars and black holes.
  - Estimate magnetic fields of neutron stars.
  - Study star birth regions and high energy processes in star systems lying beyond our galaxy.
  - Detect new briefly bright X-ray sources in the sky.
  - Perform a limited deep field survey of the Universe in the Ultraviolet region.
- At present, all the payloads are operational and are observing the cosmic sources. The spacecraft and payloads are healthy. The first six months was dedicated for performance verification and calibration of payloads .After that, the science observations by the payloads began.