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UPDATED

ANSWER WRITING WORKBOOK

Science & Technology

GS PAPER 3

Complete Science & Technology
Revision through **70+ Questions**

- Preparation Approach
- Micro Detailing of UPSC Syllabus
- 8 Practice Sets & Model Hints
- Previous Year Questions & Solutions

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PREFACE

While current affairs changes every year there are some parts in syllabus which do not change and a candidate requires conceptual understanding and a good grip over these topics. The purpose of this workbook is to serve as one stop destination for students. It will help in building a base of knowledge and conceptual clarity

GS answer writing workbook aims to function as a standalone product that will promote self-learning habits in students and help in maximum syllabus coverage of the static portion.

Features of Workbook

The workbook has following features that aim to resolve various issues faced by students in an efficient and holistic manner.

Feature	Issue resolved
Static Topics from syllabus	Conceptual clarity
Topic wise sets	Syllabus coverage
Question & Answer format	Answer writing practice & Time management
Approach before each answer	Structuring of answers
Previous Year questions	Analysis
Blank Page at the end of each set	Self-note making

- **How to optimally make use of workbook**

In order to gain maximum out of it, a student must first attempt each of the set by himself and then compare his answers with model hint given. This exercise will help them to gain confidence in answer writing, in enrichment of their answers and in better management of time.

The approach given at the beginning of each answer is also aimed to give him an idea about how to approach an answer. Before going into the answer, he must first build his own answer around the approach and then compare with the given answer.

Any extra point to be remembered, revised or any other extra additions can be made at the Blank Page given at the end of each set.

- **About GS score Science and Technology Workbook**

It consists of total 8 sets that are broadly divided as per UPSC syllabus. Focus has been given on emerging as well as prevalent technologies and various aspects and issues related with them. It is intended to serve as a reliable source of information of various ideas and concepts related to Science and technology. It will enable you to have a better grip over the subject and handle UPSC mains questions with confidence. It is essential that you must optimally utilize it as per steps given above, to extract maximum out of it.

APPROACH TO PREPARE SCIENCE AND TECHNOLOGY FOR UPSC

The one exam that expects you to know almost everything under the sun is obviously the UPSC civil services exam. The UPSC wants all candidates to have knowledge of all possible spheres be it humanities or science based subjects. Inclusion of subject like science and technology in UPSC, the commission has ensured that only those people are eligible for the highest post has sound knowledge in almost every area.

As an Arts student, this subject might be your Achilles heel, and as a science student, you are perhaps wheeling under its vastness. To excel in this subject students need to have a well-tailored strategy and planning as this subject has an important place in both prelims and mains exam.

The best strategy and resources is the one that enables minimum input and maximum output. We can say that there are 3 pillars of S&T preparation

- Study of previous year papers
- Study of Syllabus and Booklist and resources
- Strategizing

• Previous Year Papers:

To have a precise knowledge about the nature and diffi culty level of the questions the previous year papers are the best guide. If you observe the trend in the previous year's papers you will notice two things:

- The number of questions on the topic can be anywhere between 8 and 19 in the prelims exam. However the past 3 years have only seen 8 to 9 questions from Science and Technology section.
- The questions primarily focus on current happenings in the fi eld of science and tech rather than detailed theoretical knowledge.

• Study of Syllabus:

Before delving into other areas we need to understand the syllabus and structure of questions of science and technology. If we go to syllabus of science and technology in prelims exam you need to have an overview of everything, from theoretical aspects and fundamentals of Physics, Chemistry and Biology to the latest technological developments, space travel etc. But for mains syllabus one need to have an extensive study. The emphasis on the following things has to be put for the mains exam:

- Science and Technology current affairs- developments and their applications and effects in everyday life.
- Achievements of Indians in science & technology; indigenization of technology and developing new technology.
- Awareness in the fields of IT, space travel, computers, robotics, nano-technology, bio-technology and issues relating to intellectual property rights

Booklist and Resources:

- The following books and resources need to be referred for Science and Technology. This is just a suggestion the aspirants can add to some other resources as per their convenience.
- Read Class 11 and 12 NCERT to have clarity on some basic concepts.
- Offi cial website of the Department of Science and Technology. Here you will find valuable information about the new developments and policies in this field. It has been observed that a lot of times questions appear directly from official government's web portals. Therefore visit this site frequently to stay updated.
- Press Information Bureau site should be visited on regular basis to stay updated.
- One should read Science Reporter magazine. It is a monthly magazine published by the National Institute of Science Communication and Information Resources. You will find ample material here to cover both UPSC prelims and mains.
- Science and technology section in The Hindu newspaper that is featured on weekly basis.
- Update current aff airs from some good website of Civil Services Coaching such as GS Score.

Strategy for S&T

- Science and Technology section has seen some drastic changes since past few years. Due to rapid surge in technological innovations and inventions the subject has shifted slightly more towards technological section.
- Due to this subject has become more inclined towards dynamic portion or current affairs. To ease your preparation we are splitting the strategy into two portions:
- Basic Portion or Science Section
- Current Section or Technology Section
- The basic portion or science section forms the static aspect of the paper. A general overview and basic understanding of fundamental concepts is the only requirement. It is advisable to pay more attention to biology rather than chemistry and physics. Within biology too focus should be more on human anatomy than plant anatomy. Emerging fi elds such as Microbiology and biotechnology should be given more weight age and they should be linked with current aff airs while preparing notes.

Current affair is central to technology as most questions focus on it. The following areas are important:

- One should have a close vigil on Government policies and announcements in the fi eld of Technology.
- Aspirants should never skip or leave behind any new developments or initiatives enlisted by the Ministry of science and technology.
- Aspirants should be familiar with day to day technology and themes that they come across on a daily basis like RFID, GPRS, 4G, Internet of Things, Bluetooth etc..

- Take a note of the recent Noble Prize winner's research fields along with the achievements of Indians in other important forums. Any new inventions/ discoveries also need to be read. For example, the questions on Graphene and Stem Cells were asked in the exam as they pertained to new research by Noble Prize winners.

- One should be aware of ongoing research and new breakthroughs since the UPSC tends to frame questions from here. Concentrate on physics, chemistry and medicine for maximum return on time spent.

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SYLLABUS

MICRO DETAILING

SUB TOPIC LISTING (Science & Technology)

UPSC Syllabus

- Science and Technology- Developments and their Applications and Effects in Everyday Life.
- Achievements of Indians in Science & Technology; Indigenization of Technology and Developing New Technology.
- Awareness in the fields of IT, Space, Computers, Robotics, Nano-technology, Bio-technology and issues relating to Intellectual Property Rights.

EMERGING NEW TECHNOLOGIES & IPR

- What is Nanoscience and Nanotechnology?
- Origination of Nanoscience and Technology
- Basics of Nanoscience
- Nanomaterials
- Applications of nanotechnology
- Nano medicine
- Semiconductors and computing
- Food
- Textiles
- Sustainable energy
- Environment
- Transport
- Space
- Agriculture
- Adverse Health and Environmental Impacts of Nanotechnology
- Social and Ethical Impacts:
- Nano-science and nano-technology in India
- What is Robotics?
- Machine vs Computer vs Robots
- Parts of a Robot
- Controller
- Manipulator
- End Effector
- Sensor
- Classification of Robots
- Rolling Robots
- Walking Robots
- Autonomous Robots
- Artificial Intelligence
- Advantages and Disadvantages of Robot
- Applications of Robotics
- Industrial Sector
- Aerospace
- Healthcare Delivery
- Outer Space
- Exploration
- Military Robots
- Disaster Areas
- Entertainment
- Agriculture
- Domestic work
- Need for Intellectual Property Rights
- Types of IPR
- IPR Regime in India
- International Agreements Related to IPRs
- Evergreening, Compuslory Licensing

HEALTH & BIOTECHNOLOGY AND IT's APPLICATIONS

1. Genetics and biotechnology

- Industrial genetics
- Protoplast and cell fusion technologies

- Genetic engineering
- DNA sequencing
- Nucleic acid probes
- Genomics and proteomics
- Antisense and RNA interface
- Potential laboratory biohazards of genetic engineering
- Bioprocess/fermentation technology

2. Biological fuel generation

- Global warming and the significanceof fossils fuels
- Photosynthesis: the ultimate energy source
- Biofuels from biomass
- Bioethanol from biomass
- Biodiesel
- Methane
- Hydrogen

3. Environmental Biotechnology

- Microbial Ecology Environmental Biotechnology
- Waste water and sewage treatment
- Landfilling technologies
- Composting
- Bioremediation
- Detect and monitoring of pollutants
- Microbes and the geological environment
- Environmental sustainability and clean technology

4. Plant and Forest Biotechnology

- Plant biotechnology
- Forest biotechnology

5. Animal and Insect Biotechnology

- Genetic manipulation and transgenic animals
- Genetically engineered hormone and vaccines
- Animal organs for human patients
- Genetically modified insects

6. Food and beverage biotechnology

- Food and beverage fermentations
- Microorganisms as food
- Enzymes and food processing
- Amino acids, vitamins and sweeteners
- Organic acids and polysaccharides
- Public acceptance and safety of new biotechnology foods
- Biotechnology and medicine
- Pharmaceuticals and biopharmaceuticals
- Antibiotics
- Vaccines and monoclonal antibodies
- Biopharmaceuticals/therapeutic proteins
- Pharmacogenetics
- Molecular biology and human disease
- Diagnostics in developing countries
- Gene therapy
- Systems biology and medicine
- Stem cell biotechnology

7. Protection of biotechnological inventions

- Patent protection Trade secrets
- Plant breeders' rights

IT & COMMUNICATION

- Computers
- Generation of computers
- Computer terminologies
- Supercomputer and its applications
- Information technology
- Components of IT
- IT enabled services
- Application of IT
- Display technologies
- Cathode ray
- LCD
- LED
- Plasma Monitors
- OLED
- Telecommunications
- Mobile generations

- Smartfone
- Important conceps
- Computers
- Generation of computers
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- Supercomputer and its applications
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- Cathode ray
- LCD
- LED
- Plasma Monitors
- OLED
- Telecommunications
- Mobile generations
- Smartfone
- Important conceps
- Government initiatives
- Digital India Initiative
- MeghRaj
- Code Free for India
- E-Kranti
- Bharat Net project
- Bharat QR
- Contemporary debates
- Net Nuetrality
- Internet of Things
- Big Data Initiative and Privacy
- Cyber crime and security

SPACE TECHNOLOGY & SCIENTIFIC INSTITUTIONS & POLICIES

- India's policy in the field of the science and technology
- The S&T policy resolution in 1958
- S&T policy of the 1983
- S&T policy of the 2003
- S&T policy 2013
- Institutional structure
- Department of Science & Technology
- CSIR
- Survey of India
- Science and Engineering Research Council
- Technology Development Board
- National Accreditation Board For Testing And Calibration Laboratories
- Science and technology as a source of Human Resource Development
- Awards related to Science
- New Initiatives Aligned with the National Agenda
- India and World collaboration in science projects
- Technology Vision Document 2035
- National Biotechnology Development Strategy 2015-2020
- National Intellectual Property Rights Policy
- Organ donation rules in India
- Policy on Synthetic Biology
- Types of orbits
- Launch Vehicle
- Satellite communication in India
- INSAT Satellite application
- Remote sensing applications
- Cryogenic rockets
- Global Positioning System
- Galileo
- GLONASS
- IRNSS
- GAGAN
- Chandrayaan – I & II
- Mars Orbitor Mission
- Space Organisations
- Space race/Space junk
- Recent updates
- South Asia Satellite: Significance
- Neutrino Observatory

- Solar Mission- ADITYA
- Gravitational Waves
- FAST (Five-hundred-meter ApertureSpherical radio Telescope)
- Spitzer Space Telescope
- Giant Metrewave Radio Telescope
- Chandra X-ray Observatory
- James Webb Space Telescope
- ARIES/Devasthal Telescope
- Multi Application Solar Telescope
- Thirty Metre Telescope
- RESOURCESAT- 2A
- ASTROSAT
- Sunspot
- Magnetars
- Neutron stars
- Air-breathing propulsion system
- Space Junk
- Graveyard Orbit
- India, NASA join hands for Astrobiology Mission
- Neutrino Observatory
- Indian Space Vision-2025

NUCLEAR ENERGY & DEFFENCE SECTOR IN INDIA

1. Missile system and classification

- On the basis of type
- On the basis of launch vehicle
- On the basis of Range
- On the basis of propulsion system
- India's Missile System
  - Agni
  - Prithvi
  - Trishul
  - Nag
  - Dhanush
  - Astra
  - Prahaar
- BrahMos Missile System
- Indian Submarines and Naval Ships
- Light Combat Aircraft
- Unmanned Aerial Vehicle
- Stealth technology
- Chemical Weapon
- Biological Weapon
- Types of nuclear reactions
- Nuclear Power Reactor
- N-Power Policy of India
- Advantages of Nuclear Energy
- Disadvantages of Nuclear Energy
- Non-energy applications of Nuclear energy
- Impact of Radiation
- Issue of Radioactive Waste
- Institutions involved in Nuclear energy Development, AERB
- Safety standards in Nuclear Power plants
- Nuclear & Radiological Disasters

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PRACTICE QUESTIONS

SET: 1 - 8

SET-1: QUESTIONS

EMERGING NEW TECHNOLOGIES & INTELLECTUAL PROPERTY RIGHTS (IPR)

Q1. To realize the twin dreams of 'Innovate in India' and 'Make in India', the government needs to build a competitive, thriving environment by prioritizing scientific research with a strong intellectual property (IP) system. In light of the statement critically analyze the nature of India's present IP regime, the changes it requires and its importance to India's economy.

Q2. It is said that open source software are the future and patent is a drag on innovation. Examine why and also examine how India's patent rules are affecting innovation in India. Also, US Trade Representative (USTR) has again kept India on a 'priority watch list'. What does it mean to India? Critically comment if concerns raised by US regarding India's IPR laws are valid.

Q3. What do you understand by Biosimilars? How are they different from generics? Examine why Indian market for Biosimilars is an attractive one.

Q4. What is technology transfer? What are necessary scientific know-how and pre-conditions for it? Discuss its key components which make it success or failure.

Q5. Highlight key developments that depict the progressive approach taken by the Indian government towards intellectual property rights (IPR) over past few years.

Q6. Commercial applications of nanotechnology are friend as well as a foe to environmental states. Discuss the different ways in which nanotechnology can be helpful in environment management, conservation and remediation. What are the environmental concerns, ethical issues and impacts of nanotechnology used in environment engineering?

Q7. Several Government Institutions and Universities are involved in the development of robots for different applications in various fields. Discuss the various applications, challenges and robotics projects taken in India.

Q8. New Age technologies are silently but increasingly entering into Indian agriculture and hence affecting our society at large. Explain how the use of digital solutions aided with Artificial Intelligence in agriculture can uplift the farmers.

Q9. Briefly elaborate on concepts Virtual Reality (VR), Augmented Reality (VR) and Artificial Intelligence (AI), along with their role in improving social parameters like health and education.

Q10. The food industry is being revolutionized by robotics and automation. In what way applications of robotics in the agricultural industry are leading to 'Smart Farming'?

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SET-1: ANSWERS

1. To realize the twin dreams of 'Innovate in India' and 'Make in India', the government needs to build a competitive, thriving environment by prioritizing scientific research with a strong intellectual property (IP) system. In light of the statement critically analyze the nature of India's present IP regime, the changes it requires and its importance to India's economy.

(250 words)

Approach

1. **Introduction and facts** ***(40 words)***
2. **India's current IP regime** ***(80 words)***
3. **Changes required in India's IP regime** ***(80 words)***
4. **Additional information** ***(30 words)***
5. **Recent steps taken** ***(20 words)***

Hints

- Pending Patent applications were 2.37 lakh on February 1, 2016
- Pending Trademark registrations were 5.44 lakh
- Shortage of manpower
- About 58 percent of software installed in computers in India in 2015 was unlicensed

India's current IP regime:

- IP in India is regulated by several laws, rules and regulations under the jurisdiction of different ministries/departments.
- Clauses in the Patents Act of 2005 provide for a high standard of patentability, allows for compulsory licensing provisions and pre- and post-grant objection to patents. Not all of these are in tune with established international best practices.
- Enforcement environment remains challenging with high levels of physical and online piracy
- However, patent laws in India are compliant with the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS).

Importance of a strong IP regime to India's economy:

- IP has direct bearing on FDI in research and technology-oriented sectors. This would, in turn, increase economic growth, entrepreneurship, productivity, access to technology and productive employment.
- Less than 5 0,000 patent applications are filed every year in India. India attracts only 2.7 percent of global R&D spend. Some analysts attribute this to India's IP regime.
- It would foster innovation and creativity in our knowledge economy

Changes required in India's IP regime:

- While India's IP laws are robust, there is a need to review IP-related rules for better enforcement- especially to prevent and punish piracy
- Need for uniformity and harmonization in the IP policies to improve predictability, transparency and effective implementation
- Need for setting up patent benches in high courts for fast enforcement. Setting up of commercial courts is a welcome step in this direction.
- Spread more awareness among people regarding benefits of IP rights.

Additional Information:

According to GIPC (Global Intellectual Property Center), economies with robust and higher IP protection have 50 per cent more innovative output and are 40 per cent more likely to invest in research and development.

Statutes governing different kinds of IP in India are the:

- Trade Marks Act, 1999,
- Patents Act, 1970,
- Copyright Act, 1957,
- Geographical Indications of Goods (Registration and Protection), 1999,
- Protection of Plant Varieties and Farmers' Rights Act, 2001,
- Biological Diversity Act, 2002

Nodal department for trademarks, patents, designs and geographical indications is the Department of Industrial Policy & Promotion (DIPP), which functions under the Ministry of Commerce and Industry; copyright is administered by the Ministry of Human Resource Development, plant varieties and farmers' rights is administered by the Ministry of Agriculture; and biological diversity is administered by the Ministry of Environment and Forests. The 'Make in India' vision cannot survive in the long-term without concrete measures to build a concurrent 'Create in India' movement.

Recent Steps:

- In a bid to allay concerns of foreign investors regarding the country's intellectual property regime and bring in transparency, the government has initiated the online filing of patent and trademark application while sensitizing people about IPR infringement. In its annual special 301 reports 2015, the United States Trade Representatives (USTR) rapped India's IP regime, raising concerns against Section 3(d) of India's Patent Act. The report maintained India in its Priority Watch List. Commerce & Industry Ministry has appointed a 6- member IPR think tank to formulate a comprehensive national IPR Policy.

- A has released Indian Intellectual Property (IP) Panorama to increase awareness and build sensitivity towards IP in the SME sector, academia and researchers.
- The government has launched the Intellectual Property Rights (IPR) Enforcement Toolkit for Police. This toolkit will be provided to all state police departments across the nation to assist them in dealing with the cases relating to Trademarks and Copyright infringements.
- Faster Patent Approvals: The government is taking measures to reduce the time to examine patent applications for clearing them at the earliest. Now the time is between 5 and 7 years for the first examination of patent applications. The target is to bring it down to 18 months, which is the benchmark in the U.S.

Why patent approval time should be reduced

- Businesses can make timely decisions
- Business can raise benefits early and get a boost for innovation
- The product should not get obsolete before the time the patent is granted.

2. It is said that open source software are the future and patent is a drag on innovation. Examine why and also examine how India's patent rules are affecting innovation in India. Also, US Trade Representative (USTR) has again kept India on a 'priority watch list'. What does it mean to India? Critically comment if concerns raised by US regarding India's IPR laws are valid.

(250 words)

Approach

1. **Introduction and recent examples** ***(50 words)***
2. **Implications on India** ***(50 words)***
3. **Concerns raised by US** ***(50 words)***
4. **Stand of the Indian Government** ***(50 words)***
5. **Steps taken by India** ***(50 words)***

Hints

Open source software have their source codes available to public and hence any person can modify it for bettering the product. Thus it pulls innovations. Besides it is inexpensive, promotes transparency and boosts small businesses and governance. Globally we see support for open source like Free Software Movement, Copy Left, etc. Also open governance is increasingly becoming popular as governance 2.O. These promote integration of technology into governance and democratic decentralisation with added transparency. Some examples for open source software are Perl, PHP, GNU Linux, etc.

Patents can be seen as obstructions because:

- They create monopoly and suppress start-ups by monetizing even basic services.
- Evergreening helps monopolies to be extended and extract heavy royalty and penalties.

- Indian Patent Act, section 3K, mentions computer programs per se and algorithms which are not patentable. Recently released Computer Related Invention guidelines mention that only software involving novel hardware applications are patentable. This is a welcome step for start-ups in India and Digital India as we do not wish to create monopolies and aim at welfarist outcomes
- just as was our stand on Net Neutrality. History shows that innovation existed even before patent regime like web serving programs by CERN and patent-free regime may be must as it allows underlying technology to be used vastly and deploy solutions quickly. Also only22% of the patents granted by Indian Patent Office are to Indians and so there is no need to play into vested interests. However, IPR in software is a major issue for negotiating TPP. The future is moving away from expensive and limited proprietary software and increasingly governments are supporting open source platforms like SHAKTI processor at IIT Madras. However, open source software are more prone to cyber attacks

USTR Priority Watch List Issue:

USTR prepares a list of countries whose IPR regime has negative impact on American products. And US govt can put sanctions on countries listed under Section 301 Report. India has been in "priority watch list" since the beginning of the Special 301 report in 1989.

Implications on India:

- It is a warned caution to India to ensure that its IPR regime is in-line with global norms. Under extreme cases, it may lead to economic sanctions.
- It may have an adverse impact on US investments in India especially in R and D sector
- It may be next step towards more extreme category of "Priority foreign country".

Concerns raised by US:

- Issues related to Movie and Internet piracy. India doesn't have separate Anti-camcording law or severe punishment regime for such piracies (genuine concern)
- Drug Price Control Order, 2013 imposes MRP restriction on more than 350 essential drugs. But some drugs can be sold at higher prices, if they are manufactured in India using Indian technology while foreign companies have to sell same drug at a fixed. Price by National Pharmaceutical Pricing Authority

(NPPA). This hurts IPR of Pharma MNCs (invalid concern)

- Trademarks misuse and counterfeiting: India has backlog of 1.5lakh+ cases related to trademark misuse. Even FICCI report says trademark owner loose nearly $12 billion annually because of counterfeit products in Indian market (valid concern)
- India doesn't have separate law to punish trade secrets violations and relies on outdated "Contracts Act" (valid concern)
- SC ruling in Novartis/Glivec case restricting their renewal of patent (by making superficial changes in drug molecule structure) and India's Controller-General of patents order in NEXVAR judgment- giving compulsory licence to NATCO Hyderabad. MNC lobbyists have used this to wrongly portrayIndia as biased against foreign MNCs (invalid concern as it was in public interest and also complies with TRIPS)
- US companies tried to patent various Indian ancient products like neem, basmati etc. The concerns raised by people that it is a community right and should not be misused by patenting it by some US company agonized US companies. (India's concerns)

- India doesn't have separate Anti-Camcording law to combat video piracy
- India doesn't have special takedown procedures against piracy websites

Stand of the Indian Government

- India does not recognise "unilateral measures" such as the U.S. Special 301 Report that tries to create pressure on countries to enhance IPR protection beyond the World Trade Organisation's Agreement on Trade-Related Aspects of IPRs (TRIPS).
- India will not undertake commitments beyond TRIPS.
- IPR Policy will ensure that no changes are made in Section 3(d) of (Indian) Patents Act (which prevents ever-greening of drug patents) as well as the patent-disabling Compulsory

Licensing (CL).

- Compulsory licensing and norms similar to Section 3(d) are among the flexibilities available in international treaties and TRIPS Agreement to ensure availability of essential and lifesaving drugs at affordable prices.
- With rise of knowledge economy IPR regime of India surely needs overhauling; in this process US can be suitably involved to address American concerns
- Trade Facilitation and Trade Enforcement Act of 2015.
- The focus of the law is to enhance the enforcement of IPR over the U.S.'s trading partners. It introduces important measures relating to intellectual property rights (IPR) issues
- This law is expected to impact India's ability to develop an IP policy suited to its own developmental needs

How this new law aggravates the situation?

- The Act specifically requires the USTR to develop action plans with benchmarks for PWL countries. The USTR has traditionally developed action plans in consultation with the country in question. However, under Trade Facilitation Act, the USTR is not required to consult with the listed country

Steps taken by India:

- India has prepared a National IPR policy to allay apprehensions of Us government.
- The policy was drafted confirming to the World Trade Organisation's Trade-Related Aspects of Intellectual Property Rights (TRIPS).
- However, US has placed India in "Priority Watch List" owing to USTR's view that India has not made adequate changes in its intellectual property (IP) laws and regulations.
- Similar to USTR's Special 301 Report, India is being ranked poorly in the IPR index being done by the US Chamber of Commerce's Global Intellectual Property Center (GIPC).

3. What do you understand by Biosimilars? How are they different from generics? Examine why Indian market for Biosimilars is an attractive one.

(250 words)

Approach

1. **Define Biosimilars** ***(50 words)***
2. **Explain how they are different from generics** ***(80 words)***

3. **Highlight reasons why Biosimilars are attractive for Indian companies** ***(80 words)***
4. **Conclusion** ***(40 words)***

Hints

Biosimilars are biological medical product which is almost an identical copy of an original product that is manufactured by a different company. Biosimilars are officially approved versions of original "innovator" products, and can be manufactured when the original product's patent expires.

Difference between Biosimilars and Generics:

- Biologics are 200 to 1000 times the size of a small molecule (generic) drug.
- Molecular weight of biological similar is greater than generics.
- Biosimilars are structurally more complex than the generics whose structure is simple and defined.
- Biologics and Biosimilars are manufactured in living cells, then extracted and purified, whereas small molecule drugs and generics are manufactured purely via chemical synthesis.
- Generics are relatively more stable than Biosimilars as they are sensitive to handling and storage conditions.
- To get approval small clinical trials in healthy volunteers is enough for generics against larger clinical trials required for Biosimilars.
- Manufacturing quality tests for generics is way lesser than required for Biosimilars.
- There is a higher potential for adverse immune reaction in Biosimilars than generics.
- Creating imitations is therefore, very difficult in Biosimilars and many of those production details are highly-guarded intellectual property of the company that develops the initial drug.

Why Biosimilars are attractive for Indian companies?

- Indian companies, with their already existing low-cost manufacturing capabilities and strengths in small-molecule generics, have entered the Biosimilars field.
- It is estimated that 48 biological with sales of US$73 billion, will lose patent protection in the next decade, making Biosimilars a lucrative market to enter.
- Cost is a major advantage for the Indian bio-similar industry. The manufacture and development of a bio-similar molecule in India requires an estimated investment of US$10 to 20 million, compared to US$50 to 100 million in developed countries. With cost reductions of around 40% this makes India a very attractive destination for Biosimilars manufacture.
- It would also make bio-generics manufacturing an important part of the Make in India initiative.
- Indian regulators allowed companies to make biologicals early with minimum of clinical trials.
- With the introduction of insulin and erythropoietin Biosimilars, India has proved its capability to be a major contributor to this market.

- Biocon Ltd has got regulatory approval to launch the Biosimilar version of insulin glargine in Japan. Getting a successful biosimilar into a developed world market will be a feather in the cap for any Indian company.

Conclusion:

India, with 3% of the biosimilar market currently, will have at least 20-25% market share in Biosimilars market over the next five years as more than 100 major Indian pharmaceutical companies are spending largely on research pertaining to biosimilars.

4. What is technology transfer? What are necessary scientific know-how and pre-conditions for it? Discuss its key components which make it success or failure.

(250 words)

Approach

1. **Definition of technology transfer** ***(50 words)***
2. **Scientific know-how and preconditions requiredfor technology transfer** ***(80 words)***
3. **Key components that leads to its success or failure** ***(80 words)***
4. **Conclusion** ***(40 words)***

Hints

Technology transfer is the process of transferring scientific findings, knowledge, manufacturing process, technologies, processes etc. from one organization to another for the purpose of further development and commercialization. The main aim of technology transfer is to develop inventions from the lab into marketable products so that the general public at large can benefit from the research as quickly and efficiently as possible. By and large, technology transfer is accomplished through licensing intellectual property (IP) to companies that have the resources and desire to develop and produce the technology for specific applications.

Prerequisites:

- Technology Transfer is based on certain necessary scientific know-how and preconditions which are:
- Understanding of suitability of the technology to social, economic, environmental conditions.
- Capacity to evaluate the potential benefits, costs and profits: Analysis of potential of the technology to fulfil demand, for e.g. India is in need of advanced fighter aircrafts and a 3rd or 4th generation aircrafts may not be able to fulfil its requirements.
- Research and innovation ecosystem which develop technologies e.g. Universities, R&D centres of industries.
- A well-developed IPR regime which facilitates transfer of technology.
- Well-developed financial mechanisms which funds such R&D initiatives.

- Collaboration mechanisms for all the stakeholders involved.
- Strong adjudication framework to settle disputes.

Key components which make it a success or failure:

- Joint ownership, joint funding, joint control, democratic control or central assistance to the R&D projects, so that technology transfer does not become an issue at a later stage with too many negotiations and hiccups.
- Clear definition of problem whose solution is being sought through new technologies obtained through Technology Transfer.
- Analysis of market, competition, demand and targeted exploitation of market, etc.
- Periodical control and adaptation of strategy, monitoring of the success indicators.
- Equitable sharing of benefits with financial spinoffs diverted to further research.

Conclusion:

Technology transfer works to complement academic research by pushing innovations out the lab door and into the hands of industry partners who will develop them into products for the benefit of the general public.

5. Highlight key developments that depict the progressive approach taken by the Indian government towards intellectual property rights (IPR) over past few years.

(250 words)

Approach

1. **Describe IPR** ***(50 words)***
2. **Progressive developments in IPR by Indian Government** ***(150 words)***
3. **Conclusion** ***(50 words)***

Hints

Recognizing the importance of strong patent laws, India has made several progressive changes to India's patent landscape. One of the most promising advances has been to create a balance between knowledge creation and spreading awareness.

Progressive developments in IPR by Indian Government

- In the past year, a lot of IP awareness programmes were organized by the Indian government, for example, in association with research organizations, universities and industry associations.
- Cell for IPR Promotion and Management (CIPAM) regularly organized events on issues related to IPR, aiming to tread closer to the objectives of the national IPR policy.
- On the operational front, the Indian Patent Office (IPO) leaned towards technology-driven solutions – for example, by introducing the option of attending the hearing through video-conferencing – in an attempt to expedite the prosecution of patent applications while simultaneously ensuring convenience to applicants.

- The IPO invited expressions of interest for making use of artificial intelligence (AI), block chain, internet of things (IoT), and other advanced technologies for patent processing systems. Therefore, the stakeholders can expect to see further digitization of patent proceedings in India in the near future.
- The Department for Promotion of Industry and Internal Trade (DPIIT) released the draft Patent (Amendment) Rules mainly related to international applications, expedited examinations, and pre-grant opposition.
- The Indian Patent Office has also been taking commendable initiatives in partnering with IP stakeholders to augment the IP experience in India, and has regularly conducted interactive meetings with stakeholders to improve patent proceedings.
- There has been significant development with regard to procedures of the inventions utilizing biological resources from India. One such development is that the National Biological Authority (NBA) opens a window to pursue pending issues/matters under the Biological Diversity Act, 2002 (BD Act), for the users of biological resources.
- The search and examination reports generated by the IPO can now be accessed by other patent offices participating in WIPO CASE as IPO is now acting as an accessing office and providing office of WIPO CASE.
- A comprehensive National IPR policy has been approved that will not only stimulate innovation and creativity across sectors but also provide a clear vision regarding IPR issues.

Conclusion:

Clearly, recent developments in the realm of patent laws have been of a diversified nature. The efforts being made by the Indian government are quite evident and look promising for stakeholders. The constructive efforts of the government and the patent office are evident from the improved ranking of India in the recent Global Innovation Index, 2019, where India jumped 29 points to rank 52 in comparison to its 2015 ranking. We can definitely expect further improvements in the Indian IP ecosystem in times to come.

6. Commercial applications of nanotechnology are friend as well as a foe to environmental states. Discuss the different ways in which nanotechnology can be helpful in environment management, conservation and remediation. What are the environmental concerns, ethical issues and impacts of nanotechnology used in environment engineering?

(250 words)

Approach

1. **Briefly introduce nontechnology** ***(50 words)***
2. **Discuss how nanotechnology can be helpful in environment management, conservation and remediation. Explain various ethical and environmental issues** ***(150 words)***
3. **Conclusion.** ***(50 words)***

Hints

Nanotechnology can be defined as technology of rearranging and processing of atoms and molecules to fabricate materials to Nano- specifications such as a nanometre. Commercial applications of nanomaterials include carbon nanotubes, graphene, nanomedicines, Nano sensor, nanocomposites etc.

Nanotechnology has a lot of applications in environmental conservation and remediation such as-

- Generating less pollution during the manufacture of materials- use of silver nanoclusters as catalysts can significantly reduce the polluting by- products generated in the process used to manufacture propylene oxide.
- Producing solar cells that generate electricity at a competitive cost- an array of silicon nanowires embedded in a polymer results in low cost but high efficiency solar cells.
- Increasing the electricity generated by windmills- Epoxy containing carbon nanotubes is being used to make windmill blades.
- Iron nanoparticles can be effective in cleaning up organic solvents that are polluting groundwater.
- Cleaning up oil spills- Using photocatalytic copper tungsten oxide nanoparticles to break down oil into biodegradable compounds.
- Clearing volatile organic compounds (VOCs) from air- The catalyst is composed of porous manganese oxide in which gold nanoparticles have been embedded.
- Reducing the cost of fuel cells- Changing the spacing of platinum atoms used in a fuel cell increases the catalytic ability of the platinum. This allows the fuel cell to function with about 80% less platinum, significantly reducing the cost of the fuel cell.
- Storing hydrogen for fuel cell powered cars- Using graphene layers to increase the binding energy of hydrogen to the graphene surface in a fuel tank results in a higher amount of hydrogen storage and a lighter weight fuel tank. This could help in the development of practical hydrogen-fuelled cars.
- Lanthanum nanoparticles absorb phosphates from aqueous environment preventing the growth of algae in fishponds and lakes.

However, there are various ethical and environmental issues involved too-

- Inhaling airborne nanoparticles and nanofibers may lead to a number of pulmonary diseases, e.g. fibrosis.
- It may lead to Nano pollution which includes all the waste generated by manufacturing of nanomaterials and nanodevices. Due to its extremely small size, it can float in the air and might easily penetrate animal and plant cells causing undesirable effects.
- It being slowly degradable accumulates inside the body which may affect the regulatory and other mechanisms of enzymes.
- It can deepen the division of rich and poor by creating nano-divide.
- It has the potential to destabilise international relations through nano-arms race as there is a possibility of military application in biological and chemical warfare.
- Grey goo is the specific risk associated with speculative vision of molecular nanotechnology in which millions of rapidly self- replicating nanobots in their quest for fuel would consume the entire biosphere.

Conclusion:

Thus, nanotechnology is a double-edged sword that must be used judiciously so as to benefit the mankind on the whole.

7. Several Government Institutions and Universities are involved in the development of robots for different applications in various fields. Discuss the various applications, challenges and robotics projects taken in India.

(250 words)

Approach

1. **Briefly introduce robotic technology** ***(50 Words)***
2. **Applications of robots** ***(75 words)***
3. **Robotics projects in India and challenges of robotics in India.** ***(75 words)***
4. **Conclusion.** ***(50 words)***

Hints

- Robotics is a branch of science and technology which deals with design and manufacturing of robots using computer applications. It is an interdisciplinary field merging together at least mechanical, electronics and computer science engineering.
- Robot is a mechanical agent, usually an electro-mechanical machine that is guided by a computer program or electronic circuitry. Robots can be autonomous or semi-autonomous and range from humanoid to industrial robots, collectively programmed 'swarm' robots, and even microscopic nano robots.

Applications of robots:

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

- Automobile industry: industrial robots are used because of its speed, accuracy and reliability. They are used in welding, spraying and material handling.
- Electronics: used to fit chips in motherboard of a machine. These chips are very small in size and hence difficult for humans to fit it.
- Military applications: Tele robots used as UAVs to perform at dangerous far away or inaccessible places.
- Health & medicine: robotic surgery can be done, nano robots are used to take medicines to targeted organs, etc.
- Environment: nano robots can be used to clear oil spills & disassemble pollutants specially non- biodegradable ones reducing their pollution impact. Robots can be used in nuclear plants for handling & disposal of nuclear waste material.
- It is also used in Exploration ,Farms, Entertainment

Robotics projects in India

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

Challenges of robotics in India

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

Conclusion:

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

8. New Age technologies are silently but increasingly entering into Indian agriculture and hence affecting our society at large. Explain how the use of digital solutions aided with Artificial Intelligence in agriculture can uplift the farmers.

(250 words)

Approach

1. **Introduce by defining AI** ***(50 words)***
2. **Explain how it benefits the farmer. Supplement your answer with data and examples** ***(150 words)***
3. **conclude** ***(50 words)***

Hints

Artificial intelligence (AI) can be applied cross disciplinary and it can also bring a paradigm shift in how we see the farming today.AI powered Solutions will not only ebable farmers to do more with less,it will also improve quality and ensure faster go-to-market for crops.Today technology advancement in Artificial Intelligenc,BigData,IoT becoming the major drivers for providing the digital IT Solution almost in all the fields and business sectors. The following applications using AI will uplift the farmer economically and socially

Benefits of digital solutions aided with Artificial Intelligence in agriculture

- **Data Driven Farming Practices** : By analysing and correlating information about weather, types of seeds, soil quality and probability of diseases, historical data, marketplace trends, and prices, farmers will make more informed decisions.
- Precision farming is one of the most discussed areas in farming today. Drone-based images can help in in-depth field analysis, crop monitoring, scanning of fields and so on. Computer vision technology, IOT and drone data can be combined to ensure rapid actions by farmers. Feeds from drone image data can generate alerts in real time to accelerate precision farming. Companies like Aerial tronics have implemented IBM Watson IoT Platform and the Visual Recognition APIs in commercial drones for image analysis in real time.
- **Identification of optimal mix for agronomic products**: Based on multiple parameters like soil condition, weather forecast, type of seeds and infestation in a certain area and so on, cognitive solutions make recommendations to farmers on the best choice of crops and hybrid seeds. The recommendation can be further personalized based on the farm's requirement, local conditions and data about successful farming in the past. External factors like marketplace trends, prices or consumer needs may also be factored into enable farmers take a well-informed decision.
- **Automation techniques in irrigation and enabling farmers:** In terms of human intensive processes in farming, irrigation is one such process. Machines trained on historical weather pattern, soil quality and kind of crops to be grown, can automate irrigation and increase overall yield. With close to 70% of the world's fresh water being used in irrigation, automation can help farmers better manage their water problems.
- **Price prediction and market guidance**: AI helps to safeguard the farmers from market fluctuation and mitigates the risk of price loss. Based on the statistical data collected from various sources a predictive price and demand information is shared with the famers during the complete crop lifecycle. And hence the farmers can plan better for releasing their commodities to market
- Artificial intelligence (AI) is silently but increasingly entering Indian agriculture and hence affecting our society at large. Even though machine learning (which is a subset of AI) has been used for classifications and prediction purposes for, to cite a few, food grading and crop yield forecasting.

- Global population is expected to reach more than nine billion by 2050 which will require an increase in agricultural production by 70% in order to fulfil the demand. Only about 10% of this increased production may come from availability of unused lands and rest of 90% should be fulfilled by intensification of current production. In this context, use of latest technological solutions to make farming more efficient, remains one of the greatest necessities. Present strategies to intensify agricultural production require high energy inputs and market demands high quality food.

Conclusion:

- AI technologies help farmers to analyze land/soil/health of crop etc and save time and allow farmers to grow the right crop in each season that has the best yield.
- Vertical cropping can reduce water usage, make efficient land usage, can be cultivated in urban areas in buildings. It can reduce problems with labor unavailability. Allows prediction of next year crop seasons/weather/climate/rainfall etc.
- AI-based predictions enable suggesting appropriate pesticides/crops/place at right time before large scale incidence of disease.
- With a huge space still untouched in agriculture for the intrusion of automatic response systems, there is a vast opportunity for the agriculture industry to leverage emerging technology of catboats for assisting farmers with the answers to all their queries and giving relevant advice and recommendations to their specific farm-related problems. This, in turn, propels the growth of the AI market in agriculture.

9. Briefly elaborate on concepts Virtual Reality (VR), Augmented Reality (VR) and Artificial Intelligence (AI), along with their role in improving social parameters like health and education.

(250 words)

Approach

1. **Introduction on adoption of cutting edge technologies.** ***(30 words)***
2. **Explain the concepts Virtual Reality (VR), Augmented Reality (VR) and Artificial Intelligence (AI)** ***(40 words)***
3. **Role of these technologies in improving social parameters like education** ***(80 words)***
4. **Role of these technologies in improving social parameters like Health** ***(80 words)***
5. **Conclusion .** ***(20 words)***

Hints

Technology is seen as a tool to improve the social parameters across the nations especially those which are lagged behind. The gaps in education and health sector can be bridged and sustainable goals can be achieved in lesser time with effective outcomes with use of cutting edge technologies like Artificial Intelligence (AI), Virtual Reality (VR) and Augmented Reality (VR).

- **Artificial Intelligence (AI):** it is the simulation of human intelligence processes by machines, especially computer systems. These processes include learning (the acquisition of information and rules for using the information), reasoning (using the rules to reach approximate or definite conclusions) and self-correction. Particular applications of AI include expert systems, speech recognition and machine vision.
- **Virtual Reality (VR):** it is an artificial environment which is experienced through sensory stimuli (such as sights and sounds) provided by a computer. These other sensory inputs, plus some special processing of sensory information by our brains ensures that we have a rich flow of information from the environment to our minds.
- **Augmented Reality (VR):** it is enhanced version of reality where live direct or indirect views of physical real-world environments are augmented with superimposed computer-generated images over a user's view of the real-world, thus enhancing one's current perception of reality.

Role of these technologies in improving social parameters like education:

- These technologies provide more practical approach of learning rather mugging up thus help in improving learning outcomes which are very poor as per ASER report.
- They can provide Student with real world experience in Studies. For E.g. In a Botany Class you can virtually enter an organisms' body through Virtual Reality thus immersive experience and helps one visualize almost accurately, thereby accelerating learning and decision making.
- They Make Studying interesting by making them interactive and perceivable through senses. It is a fact that Human Brain easily remembers the Visuals it saw rather than the Knowledge the books provides.
- VR and AR (augmented reality) can enhance course material to a point where learning abilities grow multi-fold and students retain much more than they would with just textbooks. In short blasts of 10 or 12 minutes, VR changes the way a student experiences a subject.
- AI, can predict test performance, scores and provide solutions to long-term learning problems, even becoming AI assistants and teachers.
- **Artificial intelligence can automate basic activities in education, like grading:** While AI may not ever be able to truly replace human grading, it's getting pretty close. It's now possible for teachers to automate grading for nearly all kinds of multiple choice and fill-in-the-blank testing and automated grading of student writing may not be far behind.
- **Course improvement:** Teachers may not always be aware of gaps in their lectures and educational materials that can leave students confused about certain concepts. Artificial intelligence offers a way to solve that problem. Coursera, a massive open online course provider, is already putting this into practice. When a large number of students are found to submit the wrong answer to a homework assignment, the system alerts the teacher and gives future students a customized message that offers hints to the correct answer.

Role of these technologies in improving social parameters like health:

- VR can be used in various therapies to track body movements. This feature lets patients use the movements of their therapy exercises in an interactive way. To illustrate, VR technology can be used to build a game interface so that the patients can "play" to undergo therapy.
- VR helps in cognitive rehabilitation as well. Patients suffering from trauma often find everyday tasks to be difficult. With the help of VR, patients can practice these tasks in a safe virtual environment. By recreating the environment and steadily increasing the level of complexity, patients can surely recover from the trauma and regain their cognitive function.

- **Training:** Conventional methods of training doctors and nurses is time-consuming and expensive. But VR can be used to train doctors and nurses at reasonable costs. Healthcare professionals can practice operations, learn anatomy, and teach infection control.
- **Managing Medical Records and Other Data:** Since the first step in health care is compiling and analyzing information (like medical records and other past history), data management is the most widely used application of artificial intelligence and digital automation. Robots collect, store, re-format, and trace data to provide faster, more consistent access.
- **Doing Repetitive Jobs:** Analyzing tests, X-Rays, CT scans, data entry, and other mundane tasks can all be done faster and more accurately by robots. Cardiology and radiology are two disciplines where the amount of data to analyze can be overwhelming and time consuming. Cardiologists and radiologists in the future should only look at the most complicated cases where human supervision is useful.
- **Treatment Design:** Artificial intelligence systems have been created to analyze data – notes and reports from a patient's file, external research, and clinical expertise – to help select the correct, individually customized treatment path.
- **Precision Medicine:** Genetics and genomics look for mutations and links to disease from the information in DNA. With the help of AI, body scans can spot cancer and vascular diseases early and predict the health issues people might face based on their genetics.

Conclusion:

Technologies are not just revolutionizing how we work and our economies but also improving our life experiences. However certain challenges of related to infrastructure, accessibility, affordability and guidance of right use are needed. These technologies along with internet bridge the gender, distance and social gaps thus provide equal opportunities for all.

10. The food industry is being revolutionized by robotics and automation. In what way applications of robotics in the agricultural industry are leading to 'Smart Farming'?

(250 words)

Approach

1. **Mention the context of robotics applications in agriculture** ***(30 words)***
2. **Derive link between use of robotics and Smart Farming.** ***(80 words)***
3. **Explain applications of robots for smart farming.** ***(80 words)***
4. **Major concerns in use of agricultural robots.** ***(40 words)***
5. **Conclusion.** ***(20 words)***

Hints

- Farmers are eyes of our country. Because the demand for food is outpacing available farmland and it's up to farmers to close this gap. Agricultural robots are helping them do just that.
- Automated agriculture is going from strength to strength. **It is replacing the common techniques to perform the same tasks with high efficiency.**

- According to both the Government and farmers, the future of farming is one in which small robots will have a crucial role to play.

Applications of robots for smart farming:

The "smart farming" or "precision farming," is a key component of sustainable intensification. This combines remote sensing, robotics, big data analytics, artificial intelligence, and other emerging technologies into an integrated high-resolution crop production system.

Following are the real-life applications of robots for smart farming:

- **Crop seeding**: The traditional method for sowing seeds is to scatter them using a broadcast spreader attached to a tractor. It is not a very efficient method of planting as it can waste seeds. The tractor, with robotic seeding attachment, then places the seeds at precise locations and depths so that each has the best chance of growing.
- **Automatic Watering and Irrigation**: Using robotics sensors, the continuous monitoring of moisture levels and plant health can be done. It enables farmers to intervene only when necessary.
- **Weeding and Crop Maintenance**: Weeding and pest control are both critical aspects of plant maintenance and tasks that are perfect for autonomous robots. The same base machine can be equipped with sensors, cameras and sprayers to identify pests and application of insecticides.
- **Picking and Harvesting**: The crops, like soft fruits, are more difficult to harvest as they require manual dexterity. So clever robots can use in harvesting applications, including apple harvesting, grape picking and sweet pepper picking.
- **Crop Spraying:** There are also drones currently available and in development for crop spraying applications, offering the chance to automate yet another labor-intensive task. Using a combination of GPS, laser measurement and ultrasonic positioning,
- **Drones for Imaging**: This land telemetry, soil and crop data allow the grower to monitor, plan and manage the farm more effectively saving time and money along with reducing the use of pesticides.

Major concerns in the use of agricultural robots:

- **It costs a lot of money to make or buy robots, also they need maintenance to keep them running.**
- **The small landholders and marginal farmers cannot afford it and so, cannot compete with large ones.**
- **The robots can change the culture/the emotional appeal of agriculture in India.**

Conclusion:

- It's still early days for smart agriculture. But there are clearly huge opportunities for farming with small, lightweight and autonomous equipment.
- It will improve the quality of life for farmers and will attract the youths in farming activities.

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