Science & Technology · GS - III

The Voyager missions represent a landmark in humanity's exploration of deep space. Examine their scientific significance and discuss the technological challenges involved in sustaining communication with spacecraft operating in interstellar space.

EXAM YEAR	PAPER	SUBJECT
DAILY PRACTICE 18/11/2026	GS - III	Science & Technology

MARKS	WORD LIMIT
15	~250 words

Answer Hint

Deep-space exploration, Voyager 1 and 2, planetary science, heliosphere, interstellar medium, radioisotope power, Deep Space Network, signal delay, ageing technology, international scientific cooperation.

Model Answer

Modal Answer

Introduction

Launched in 1977, NASA's Voyager 1 and Voyager 2 missions transformed our understanding of the outer Solar System. Voyager 1 has travelled into interstellar space and continues to provide valuable scientific information.

Scientific Significance

- **Planetary exploration:** The missions provided detailed observations of Jupiter and Saturn, including their moons, rings and atmospheric features.
- **Interstellar research:** Voyager 1 crossed the heliopause in 2012, enabling direct measurements of the interstellar environment.
- **Heliosphere studies:** Their observations improved understanding of the interaction between the solar wind and interstellar medium.
- **Human knowledge:** The Golden Record aboard each spacecraft represents an attempt to communicate aspects of human civilisation beyond Earth.

Technological Challenges

- **Power limitations:** Radioisotope thermoelectric generators gradually lose electrical output, requiring instruments and systems to be switched off.
- **Communication delay:** Signals take many hours to travel between Earth and the spacecraft.
- **Signal weakness:** Enormous distances require highly sensitive antennas and NASA's Deep Space Network.
- **Ageing components:** Maintaining decades-old onboard systems requires innovative engineering and careful resource management.
- **Navigation:** Precise tracking and communication become increasingly difficult as spacecraft move farther away.

Way Forward

Continued investment in deep-space communication networks, advanced propulsion, radiation-resistant electronics and long-life power systems is essential for future exploration.

Conclusion

Voyager demonstrates how sustained scientific investment and engineering innovation can extend humanity's reach beyond the Solar System. Its legacy provides a foundation for future interstellar research.

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