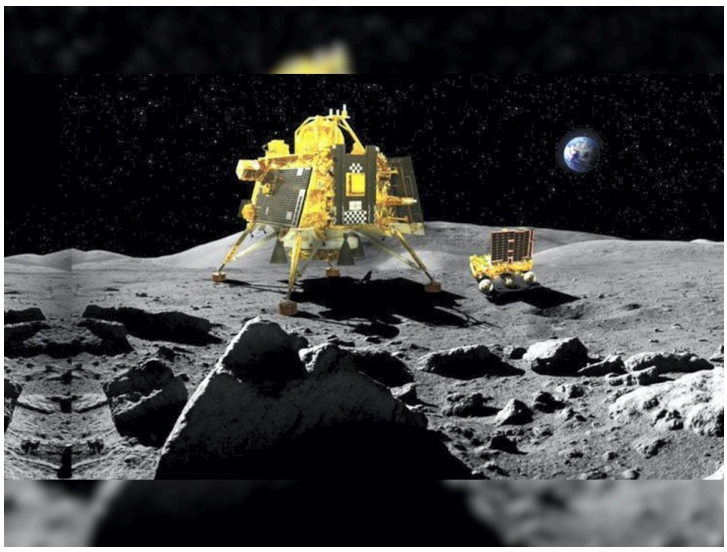
GOVERNMENT DEGREE COLLEGE (AUTONOMOUS)

TUNI, KAKINADA Dt., ANDHRA PRADESH-533401

(Re-Accredited By NAAC With 'B' Grade)

(Affiliated To Adikavi Nannaya University, Rajamahendravaram)



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Chandrayaan-3 is India's third lunar exploration mission, launched by the Indian Space Research Organisation (ISRO) in July 2023, with a primary goal to achieve a soft landing on the Moon. This mission builds upon lessons learned from Chandrayaan-2, whose lander experienced a crash landing in 2019. Chandrayaan-3 made India the fourth country (after the US, Soviet Union, and China) to successfully achieve a soft landing on the Moon, and the first to land near the lunar south pole, a region of scientific interest for its potential water ice deposits.

Key Components and Objectives

Chandrayaan-3 consists of three main parts: a Lander Module (LM), a Rover, and a Propulsion Module (PM). The primary objectives of Chandrayaan-3 were to:

1. Achieve a safe and precise soft landing on the Moon.
2. Operate the rover on the lunar surface to conduct in-situ scientific experiments.
3. Collect and analyze data on the Moon's surface composition, mineralogy, and seismic activity.

Technological Innovations and Challenges

To ensure the mission's success, ISRO incorporated advanced technologies in guidance, navigation, and control. The lander, named Vikram, was equipped with sensors, altimeters, velocimeters, and hazard-avoidance systems to manage a controlled descent despite the Moon's low-gravity environment. Vikram deployed a small rover, Pragyan, which analyzed lunar soil and transmitted data back to Earth.

Scientific Contributions and Future Implications

Chandrayaan-3 aims to deepen our understanding of the Moon's geology, especially in polar regions that are believed to contain water ice, which could support future manned missions and resource utilization. This mission also enhances India's standing in global space exploration and opens opportunities for international collaboration

What does the chandrayaan-3mission says about

One of the major goals of Chandrayaan-3 was to hunt for water, as scientists believe that the huge craters in the south polar region, which are permanently in shadow, hold ice that could support human habitation on the Moon in the future.

Chandrayaan 3: Sulphur Discovery

The Chandrayaan-3 Rover's LIBS instrument made a ground breaking discovery by confirming the presence of sulphur (S) on the Moon's southern surface. This finding is significant because previous tools onboard orbiters couldn't determine sulphur's presence. The Laser-Induced Breakdown Spectroscopy (LIBS) instrument played a key role in this important lunar exploration.

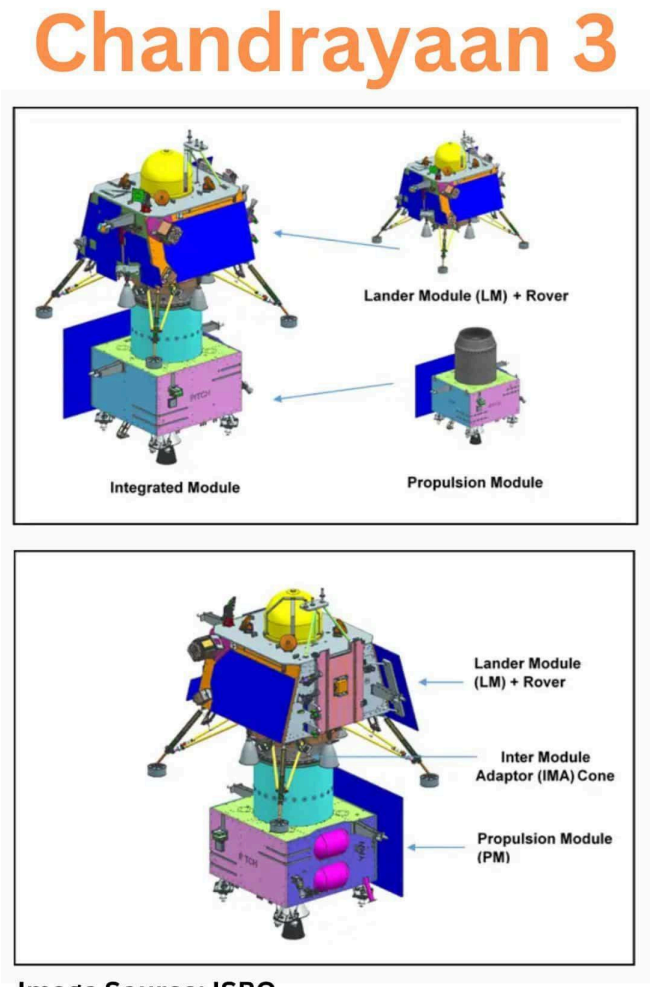


Image Source: ISRO

Chandrayaan-3 Instruments and tools

1. Propulsion Module:

The part that makes the spacecraft move i.e. the propulsion module will take the lander and rover towards the Moon's orbit, about 100 kilometers above its surface. This part also has a tool called SHAPE (Spectro-polarimetry of Habitable Planet Earth), which helps study Earth from the Moon by looking at its colours and light properties.

2. Lander:

The things that the lander carries include:

Jagranjosh

i) ChaSTE (Chandra's Surface Thermophysical Experiment), which measures how heat moves through the Moon's surface and its temperature.

ii) ILSA (Instrument for Lunar Seismic Activity), which listens for ground movements (like earthquakes) near where the lander lands.

iii) LP (Langmuir Probe), which figures out how many charged particles are around the lander and if they change.

iv) Laser Retroreflector Array - A special mirror from NASA that reflects lasers from Earth to help us measure distances on the Moon.

3. Rover:

Jagranjosh

The rover's tools are:

i) APXS (Alpha Particle X-ray Spectrometer), which checks what elements are present near the landing area using special particles.
ii) LIBS (Laser Induced Breakdown Spectroscope), which uses lasers to break down materials and see what they're made of.
Chandrayaan 3: Advanced Technologies
To meet the mission goals, the Lander incorporates a range of advanced technologies, including:

1. Height Measuring Devices: Altimeters that use lasers and radio frequency signals.

2. Speed Measuring Tools: Laser Doppler Velocimeter and a Camera to track the Lander's horizontal speed.

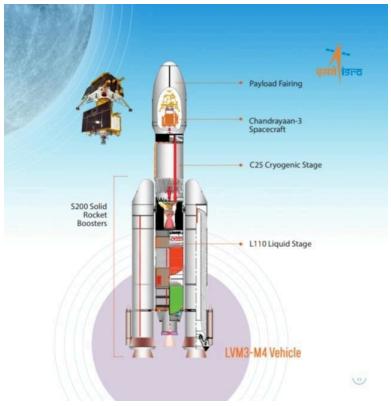
3. Motion Tracking Equipment: Inertial Measurement system based on Laser Gyros, along with an Accelerometer package.

4. Propulsion System: Throttleable Liquid Engines with a thrust of 800N, smaller 58N thrusters for controlling orientation, and the associated engine control electronics.

5. Navigation, Guidance & Control (NGC): Software and planning for the Lander's powered descent trajectory.

6. Identifying and Avoiding Dangers: Cameras and algorithms to detect and navigate away from hazards during landing.

7. Mechanism for Landing Legs. The mechanism for landing involves various steps like rover deployment, communication setup, rover exploration, data transmission, and communicating information to the earth



What is the hard work behind the chandrayaan-3

Who designed Chandrayaan-3 :
Mitul Trivedi

One of the major goals of Chandrayaan-3 was to hunt for water, as scientists believe that the huge craters in the south polar region, which are permanently in shadow, hold ice that could support human habitation on the Moon in the future.

Significance of Chandrayaan-3 :

1.Scientific research
2.Technological advancements
3.Lunar exploration
4.International collaboration
5.Inspiring future generations
6.Economic benefits
7.Global collaboration and inspiration

How does the mathematics, used in chandrayaan-3 mission

Mathematics played an essential role in the Chandrayaan-3 mission by the Indian Space Research Organisation (ISRO). Here are some of the critical areas where mathematical applications were crucial to the mission's success:

1. **Orbital Mechanics and Trajectory Calculations**

Orbital Mechanics: Mathematical calculations in orbital mechanics helped determine the spacecraft's trajectory around Earth and its transfer to the Moon.
Trajectory Optimization: Calculus, differential equations, and optimization techniques ensured Chandrayaan-3 followed the most fuel-efficient path, balancing speed and fuel use.
Transfer Orbit Calculation: The Hohmann transfer, a common method for moving between two orbits, relies on specific velocity calculations at each point of the mission.

2. **Navigation and Guidance**

Astrodynamics: Mathematics models Chandrayaan-3's motion under the influence of gravitational forces from Earth, Moon, and the Sun.
Kalman Filtering: This mathematical algorithm continuously estimated the spacecraft’s position and velocity by combining sensor data and predictions to adjust course if needed.

Guidance Algorithms: These mathematical algorithms helped navigate the mission from Earth orbit to Moon orbit and eventually to lunar landing.

3. **Landing Dynamics**

Control Systems: Advanced mathematics in control theory managed the descent by calculating the thrust, orientation, and velocity necessary to achieve a soft landing.

Kinematic Equations and Descent Speed: Solving differential equations for position, velocity, and acceleration was critical in planning a safe descent trajectory.

Gravitational Field Analysis: Mathematical modeling of the Moon's gravitational field helped correct the descent trajectory and avoid deviations due to uneven lunar gravitational pull.

4. **Communication Systems:**

Signal Processing: Fourier transforms and other mathematical tools helped ensure clear communication by modulating and demodulating signals sent between Earth and Chandrayaan-3.

Error Correction Codes: Advanced algebraic structures like Reed-Solomon codes were used for error detection and correction in data transmitted over vast distances.

5**. Data Analysis and Image Processing**

Image Analysis: Algorithms based on linear algebra and calculus enabled the processing of images and data received from the Moon.

Surface Mapping and Topography: Calculus and geometry helped generate precise maps of the lunar surface, aiding in scientific analysis and future missions.

6. Thermal Analysis

Heat Transfer Equations: Mathematical equations modeling heat conduction, convection, and radiation ensured the spacecraft could withstand temperature changes in space.

Finite Element Analysis (FEA): This method divided the spacecraft into small elements to analyze temperature distribution and optimize insulation and cooling systems.

7. Machine Learning for Autonomous Decision-Making

Predictive Modeling: Machine learning models, often based on statistical mathematics, helped predict system behavior, especially in high-risk stages like landing.

Anomaly Detection: Statistical models identified and managed potential issues by recognizing outliers or deviations in system performance.

8. Structural Analysis

Finite Element Method (FEM): FEM was used to analyze the spacecraft's structure, ensuring it could withstand the forces of launch, space travel, and landing.

Stress and Strain Calculations: Differential equations helped calculate how the structure would respond to various loads, vibrations, and thermal stresses.

References:

(https://yourstory.com/2023/08/chandrayaan-3-isro-space-tech-lunar-mission).