"Dissecting a Space Odyssey" Systematic Study of Path travelled by LMV3 of Chandrayaan-3

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Abstract - *This research paper summarizes the "Distance Travelled by Chandrayan-3 along with its mathematical equation." The data has been taken from ISRO's official website and Social Media Handles. For this we have used different mathematical formulas, analyzed it graphically and structured it in the form of a research paper.*

***Key Words*: Chandrayaan-3, Maneuver, LMV3, Elliptical, Orbits**

1. Introduction

Countries nowadays are spending a large sum of money to reach and study outer-space and extra-terrestrial lands. USA was first country to land on moon but according to Outer space treaty no country can own moon if they have flag on it or not. Space Exploration was born after World War 2 when USA and Russia were competing to see who is best in technological aspect. Russia was successful in sending the first artificial satellite whereas USA was successful in first manned mission to moon. Other countries were also eager to take part in space race, India being one of them.

1.1 Astrophysics:

Astrophysics is a branch of astronomy that focuses on the study of the physical properties and behavior of celestial objects and phenomena in the universe. It seeks to understand the fundamental processes and principles that govern the behavior of stars, planets, galaxies, black holes, and other cosmic entities.

Here are some key areas of study within astrophysics:

a. Stellar Astrophysics: This field focuses on the study of stars, including their formation, evolution, and eventual fate. It explores the processes of nuclear fusion that power stars and the different stages of a star's life, from birth to supernova explosions or the formation of compact objects like white dwarfs, neutron stars, or black holes.
b. Exoplanetary Science: Exoplanetary science involves the study of planets that orbit stars outside our solar system, known as exoplanets. Researchers in this field are interested in identifying and characterizing exoplanets, including their atmospheres, potential habitability, and the possibility of extraterrestrial life.
c. Galactic and Extragalactic Astrophysics: This area of study examines the large-scale structure and dynamics of galaxies and galaxy clusters. It seeks to understand the formation and evolution of galaxies, as well as the distribution of matter in the universe. This field also explores topics such as dark matter and dark energy.
d. Cosmology: Cosmology is the study of the origin, evolution, and fate of the universe as a whole. Astrophysicists in this field investigate the Big Bang theory, cosmic microwave background radiation, the expansion of the universe, and the large-scale structure of spacetime.
e. High-Energy Astrophysics: High-energy astrophysics deals with extremely energetic phenomena in the universe, such as gamma-ray bursts, supernovae, quasars, and the behavior of matter under extreme conditions, such as in the vicinity of black holes and neutron stars.
f. Cosmochemistry: Cosmochemistry examines the chemical composition of celestial bodies, including planets, asteroids, comets, and meteorites. It helps us understand the origin and evolution of chemical elements in the cosmos.
g. Black Holes and Neutron Stars: Research in this area delves into the properties and behavior of black holes and neutron stars, which are some of the most extreme and mysterious objects in the universe.

Astrophysicists use a combination of observational data, theoretical models, and advanced technology, including telescopes, satellites, and computer simulations, to advance our understanding of the universe's physical properties and its underlying mechanisms. This field plays a crucial role in answering some of the most profound questions in science, such as the nature of dark matter and dark energy, the origin of the universe, and the potential for life beyond Earth.

1.2 ISRO and its history:

The Indian Space Research Organisation (ISRO) boasts a remarkable history of scientific and technological achievements since its founding in 1969. Under the visionary leadership of Dr. Vikram Sarabhai, ISRO was established with the mission of harnessing space technology for peaceful and developmental purposes. ISRO's journey began with the launch of its first satellite, Aryabhata, in 1975, marking India's entry into the space age. Over the years, ISRO has made significant strides, including developing its own satellite launch capabilities, deploying communication and Earth observation satellites, and venturing into interplanetary exploration.

It has since become one of the world's leading space agencies, known for its cost-effective and innovative approach to space missions.

Here are some key aspects and achievements of ISRO:

1. Mars Orbiter Mission (Mangalyaan): In 2013, ISRO successfully launched the Mars Orbiter Mission, also known as Mangalyaan. It made India the fourth space agency in the world to reach Mars and the first to do so on its maiden attempt.
2. Chandrayaan Missions: ISRO has launched two lunar missions. Chandrayaan-1, launched in 2008, made significant discoveries about the presence of water molecules on the Moon. Chandrayaan-2, launched in 2019, included an orbiter, a lander (Vikram), and a rover (Pragyan), although the lander encountered difficulties during its descent.
3. Aditya L1: Aditya-L1 mission is a planned solar observation mission by the Indian Space Research Organization (ISRO). The primary objective of this mission is to study the Sun, particularly its outermost layer, called the corona, and the impact of solar activities on Earth's climate
4. Navigation: ISRO developed the Indian Regional Navigation Satellite System (IRNSS), later renamed NavIC
5. (Navigation with Indian Constellation). NavIC is a regional satellite navigation system that provides accurate position information service to users in India and surrounding regions.
6. Earth Observation: ISRO operates a series of Earth observation satellites that provide crucial data for applications such as weather forecasting, disaster management, agriculture, and resource management.
7. Communication Satellites: ISRO has launched numerous communication satellites, such as the INSAT and GSAT series, to enhance India's telecommunications infrastructure and provide connectivity services.
8. International Collaborations: ISRO collaborates with various international space agencies and organizations on joint missions and projects. It has also launched satellites for other countries as part of commercial launches.

1.3 Chandrayan Mission:

The Chandrayan missions are lunar exploration missions conducted by the Indian Space Research Organisation (ISRO). There have been three Chandrayaan missions:

1. Chandrayan 1:

Chandrayaan-1 was India's first lunar exploration mission, launched by the Indian Space Research Organisation (ISRO). It was launched on October 22, 2008, and it marked a significant milestone in India's space exploration efforts. The primary objectives of Chandrayaan-1 were to:

a. Conduct high-resolution remote sensing of the moon in visible, near-infrared, and X-ray spectra.
b. Perform chemical and mineralogical mapping of the lunar surface.
c. Study the moon's topography and terrain.

Chandrayaan-1 was equipped with a variety of scientific instruments, including the Moon Impact Probe (MIP), which was designed to impact the lunar surface and provide additional data. However, the MIP was released prematurely during the mission, and it was not able to achieve its intended purpose. Despite this setback, Chandrayaan-1 was able to collect valuable data about the moon's surface and composition during its mission. One of its most significant discoveries was the presence of water molecules on the lunar surface, particularly at the moon's poles. This discovery was important because it suggested the possibility of water ice on the moon, which could be a valuable resource for future lunar exploration. Chandrayaan-1's mission was cut short in August 2009 when ISRO lost contact with the spacecraft. Initially thought to be lost forever, NASA's Lunar Reconnaissance Orbiter (LRO) discovered Chandrayaan-1's remains in lunar orbit in 2016. Chandrayaan-1 paved the way for subsequent Indian lunar missions, including Chandrayaan-2, which aimed to build upon the knowledge gained from the first mission and included an orbiter, a lander (Vikram), and a rover (Pragyan). Chandrayaan-2 was launched in July 2019.

2. Chandrayan 2:

Chandrayaan-2 is India's second lunar exploration mission, following the success of Chandrayaan-1. It was launched by the Indian Space Research Organisation (ISRO) and was designed to build upon the knowledge gained from the first mission while also expanding India's capabilities in lunar exploration. Chandrayaan-2 had three main components:

A. Orbiter: The orbiter is designed to orbit the Moon and conduct remote sensing observations. It carries a suite of scientific instruments to study the Moon's surface, mineral composition, and exosphere. The orbiter is intended to provide valuable data about the Moon from lunar orbit.
B. Lander (Vikram): The lander, named Vikram, was designed to make a soft landing on the lunar surface near the South Pole of the Moon. It was equipped with scientific instruments to study the lunar surface and conduct experiments. The goal of Vikram was to explore the surface in close proximity and provide data about the Moon's geology.
C. Rover (Pragyan): The rover, named Pragyan, was housed within the lander Vikram. It was designed to traverse the lunar surface, analyze soil samples, and perform experiments. The rover was intended to enhance our understanding of the Moon's composition and surface properties.

Chandrayaan-2 was launched on July 22, 2019, aboard a GSLV Mk III-M1 rocket. While the orbiter successfully entered lunar orbit and continues to study the Moon, the lander Vikram encountered difficulties during its descent to the lunar surface. Unfortunately, it lost communication with ISRO mission control, and its status remained uncertain for some time.
Despite the challenges with the lander, the Chandrayaan-2 mission is considered a significant achievement for ISRO, as it demonstrated India's capability to send an orbiter to the Moon and attempt a soft landing. The orbiter continues to send valuable data back to Earth and contribute to our understanding of the Moon. Chandrayaan-2 represents India's continued commitment to lunar exploration, and it has paved the way for future missions to explore and utilize the Moon's resources.

3. Chandrayan 3:

Chandrayaan-3 is an Indian lunar mission that was launched on 14 July 2023. It is the third Indian lunar mission, and the successor to the Chandrayaan-2 mission, which was launched in 2019 but failed to land on the Moon safely. Chandrayaan-3 consists of a lander and a rover, but it does not have an orbiter. The lander is named Vikram, and the rover is named Pragyan. Vikram is scheduled to land at the Shackleton crater, which is located near the South Pole of the Moon.

The main objectives of the Chandrayaan-3 mission are to:

- Demonstrate the ability to land a spacecraft on the Moon
- Explore the lunar South Pole region, which is relatively unexplored
- Study the lunar surface and subsurface
- Search for water and other resources on the Moon

The Chandrayaan-3 mission is a significant milestone for India's space program. If successful, it will make India the fourth country to land a spacecraft on the Moon, after the United States, the Soviet Union, and China. The mission is also significant because it is the first time that India is attempting to land a spacecraft on the lunar South Pole. The South Pole region is of particular interest to scientists because it is thought to be home to water ice and other resources. The Chandrayaan-3 mission is expected to last for about 14 days. The Vikram lander will conduct experiments on the lunar surface, and the Pragyan rover will explore the surrounding area. The Chandrayaan-3 mission is a challenging one, but it has the potential to make major contributions to our understanding of the Moon. It is also a sign of India's growing ambition in space exploration.

2. Chandrayaan-3 in Detail:

Chandrayaan 3 was planned after the unsuccessful landing of lander of Chandrayaan-2. On 22 July, 2019, ISRO launched Chandrayaan-2 mission with Lunch vehicle mark-3(LVM3) which consists of orbiter, lander and rover. Orbiter was successful in setting up orbit around but during landing, ISRO lost contact with lander deviating from its original trajectory and crashed.

After the first try, ISRO launched theird edition to chandrayaan mission on 14 July, 2023 and lander successfully landed on 23 august, 2023.

Chandrayaan-3 comprises three main components: a propulsion module, lander, and rover.
LMV3 was the main spacecraft consisting of Propulsion module, Lander and Rover.
We will calculate equations and distance of LMV3 of Chandryaan-3.

Elements of Chandrayan-3:

1. Propulsion module:

The propulsion module of Chandrayaan-3 is a spacecraft component that is responsible for carrying the lander rover module to the Moon and placing it in orbit around the Moon. It also carries a scientific payload called SHAPE (Spectro-polarimetry of Habitable Planet Earth), which will study the Earth's atmosphere and surface from the Moon.

The propulsion module is a box-shaped spacecraft with dimensions of 3.2 meters by 2.2 meters by 2.2 meters. It is powered by a 110N liquid bipropellant engine, which uses monomethylhydrazine (MMH) and nitrogen tetroxide (N_2O_4) propellant.

The propulsion module is equipped with a variety of sensors and instruments, including:

- Star sensors: These sensors are used to determine the spacecraft's attitude (orientation) relative to the stars.
- Sun sensors: These sensors are used to determine the spacecraft's attitude relative to the Sun.
- Inertial measurement unit (IMU): This instrument measures the spacecraft's acceleration and rotation rates.
- Global positioning system (GPS) receiver: This receiver is used to determine the spacecraft's position in orbit.

The propulsion module also carries a variety of communication systems, which are used to communicate with the ground stations on Earth. The propulsion module of Chandrayaan-3 is a critical component of the mission. It is responsible for carrying the lander rover module to the Moon and placing it in orbit around the Moon. It also carries a scientific payload that will study the Earth's atmosphere and surface from the Moon.

2. Vikram Lander:

The Vikram lander is the spacecraft component of Chandrayaan-3 that is responsible for landing the spacecraft on the Moon. It is named after Vikram Sarabhai, the father of the Indian Space Programme.

Vikram lander is a box-shaped spacecraft with dimensions of 2.1 meters by 2.1 meters by 2.1 meters. It is powered by four 800-newton liquid bipropellant engines, which use monomethylhydrazine (MMH) and nitrogen tetroxide (N_2O_4) propellant.

The Vikram lander is equipped with a variety of sensors and instruments, including:

- Star sensors: These sensors are used to determine the spacecraft's attitude (orientation) relative to the stars.
- Sun sensors: These sensors are used to determine the spacecraft's attitude relative to the Sun.
- Inertial measurement unit (IMU): This instrument measures the spacecraft's acceleration and rotation rates.
- Global positioning system (GPS) receiver: This receiver is used to determine the spacecraft's position in orbit.

The Vikram lander also carries a variety of communication systems, which are used to communicate with the ground stations on Earth. The Vikram lander is a critical component of the Chandrayaan-3 mission. It is responsible for landing the spacecraft on the Moon and deploying the Pragyan rover.

3. Pragyan rover:

The Pragyan rover is the spacecraft component of Chandrayaan-3 that is responsible for exploring the lunar surface. It is named after the Sanskrit word for "wisdom.
The Pragyan rover is a six-wheeled vehicle with a length of 1.7 meters, a width of 1.5 meters, and a height of 0.7 meters. It weighs about 27 kilograms.

- The Pragyan rover is equipped with a variety of sensors and instruments, including: Panoramic camera: This camera will take images of the lunar surface.

- Alpha particle X-ray spectrometer (APXS): This instrument will identify the chemical composition of the lunar surface.
- Laser induced breakdown spectroscopy (LIBS): This instrument will identify the elemental composition of the lunar surface.
- Magnetometer: This instrument will measure the magnetic field of the Moon.
- Radiometer: This instrument will measure the temperature of the lunar surface.

The Pragyan rover is designed to travel up to 500 meters on the lunar surface. It is expected to operate for about 14 days. The Pragyan rover is a critical component of the Chandrayaan-3 mission. It is responsible for exploring the lunar surface and collecting data on the Moon's composition and geology.

3. Mission Profile:

Chandrayaan-3 was launched aboard an LVM3-M4 rocket on 14 July 2023, at 09:05 UTC from Satish Dhawan Space Centre Second Launch Pad in Sriharikota, Andhra Pradesh, India, entering an Earth parking orbit with a perigee of 170 km (106 mi) and an apogee of 36,500 km (22,680 mi).

Below is the table for Stages of Chandrayan-3 deployment and flight:

Stage and Sequence	**Date / Time**	**Orbit**
Earth Orbit: Launch	14 July 2023	170 km x 36500 km
Earth bound maneuvers:1	15 July 2023	173 km x 41762 km
Earth bound maneuvers:2	17 July 2023	226 km x 41603 km
Earth bound maneuvers:3	18 July 2023	228 km x 51400 km
Earth bound maneuvers:4	20 July 2023	223 km x 71351 km
Earth bound maneuvers:5	25 July 2023	236 km x 127603 km
Trans Lunar injection	31 July 2023	288 km x 169328
Lunar bound maneuvers:1	05 August 2023	164 km x 18074 km
Lunar bound maneuvers:2	06 August 2023	170 km x 4313 km
Lunar bound maneuvers:3	09 August 2023	174 km x 1437 km
Lunar bound maneuvers:4	14 August 2023	150 km x 177 km
Lunar bound maneuvers:5	16 August 2023	153 km x 163 km
Lander deorbit maneuvers: 1	18 August 2023	113 km x 157 km
Lander deorbit maneuvers: 2	19 August 2023	25 km x 134 km
Landing	23 August 2023	-
Rover deployment	23 August 2023	-

4. What is a Maneuver:

In space exploration, maneuvers refer to planned and controlled changes in the position, velocity, or trajectory of spacecraft. These maneuvers are critical for various aspects of space missions, including:

1. Orbit Changes: Spacecraft often need to change their orbits for a variety of reasons, such as getting into the desired orbit around a celestial body (e.g., Earth, Mars, or the Moon) or transitioning between different phases of a mission. These maneuvers are accomplished by firing onboard thrusters or engines at specific times and directions to alter the spacecraft's velocity and trajectory.
2. Rendezvous and Docking: When two spacecraft need to meet and dock in space, precise maneuvers are required to ensure a safe and accurate approach. These maneuvers involve adjusting the relative positions and velocities of the two spacecraft.
3. Landing and Descent: For missions involving planetary or lunar landers, maneuvers are essential for controlled descent and landing on the target body. These maneuvers often include course corrections to ensure a precise landing location.

4. Trajectory Corrections: During long-duration missions, spacecraft may need to make periodic trajectory corrections to account for variations in gravitational forces, errors in navigation, or to optimize the mission's path.
5. Flybys and Gravity Assists: Some missions use the gravitational pull of celestial bodies (e.g., planets) to change their trajectory or gain speed. These gravity-assist maneuvers are carefully planned to maximize the mission's efficiency.
6. Station-Keeping: In missions involving multiple spacecraft or satellites in close proximity, maneuvers are performed to maintain a stable position relative to each other, such as in Earth observation satellite constellations or space station docking.

These maneuvers require precise calculations, careful planning, and often real-time monitoring and adjustments to ensure the success of a space mission. They are typically executed using onboard propulsion systems and are a fundamental aspect of space exploration and navigation.

5. Elliptical Orbit:

Elliptical orbits are a common type of orbit used by spacecraft for various purposes, including Earth observation, communication, scientific exploration, and interplanetary missions. Here are some key aspects of elliptical orbits for spacecraft:

1. Definition: An elliptical orbit is a type of Keplerian orbit, characterized by its shape, which resembles an elongated or flattened circle. In an elliptical orbit, the spacecraft follows an elliptical path around a celestial body, such as a planet or the Sun.
2. Foci: An elliptical orbit has two foci (plural of "focus"). These foci are located along the major axis of the ellipse. The sum of the distances from any point on the orbit to the two foci remains constant.
3. Semi-Major Axis: The semi-major axis (denoted as "a") is half the length of the major axis of the ellipse. It is a critical parameter that determines the size of the orbit. The semi-major axis also defines the average distance between the spacecraft and the central body.
4. Eccentricity: Eccentricity (denoted as "e") is a measure of how elongated the ellipse is. It ranges from 0 (for a perfect circle) to 1 (for a highly elongated ellipse). The value of eccentricity determines how much the orbit deviates from a circular shape. Elliptical orbits have eccentricities between 0 and 1.
5. Periapsis and Apoapsis: In an elliptical orbit, the point closest to the central body is called the "periapsis" or "perigee" (for Earth orbits), and the point farthest from the central body is called the "apoapsis" or "apogee" (for Earth orbits). The distances from the central body to the periapsis and apoapsis are critical parameters for mission planning.
6. Orbit Dynamics: In an elliptical orbit, the spacecraft's speed varies as it moves along its path. It travels faster at the periapsis and slower at the apoapsis. This variation in speed is governed by Kepler's laws of planetary motion.
7. Orbit Changes: Spacecraft in elliptical orbits can change their orbit shape and size by performing orbital maneuvers. These maneuvers may involve firing thrusters to increase or decrease speed, change the orientation of the orbit, or transfer to a different type of orbit.

Elliptical orbits offer flexibility in mission planning, allowing spacecraft to meet specific objectives, such as close encounters with celestial bodies or efficient use of propulsion systems. They are commonly used in space exploration and satellite operations.

<u>General Equation of Ellipse:</u>

$$\frac{(x-h)^2}{a^2}+\frac{(y-k)^2}{b^2}=1$$

Where,

- Length of Major Axis=2a
- Length of Minor Axis= 2b
- Coordinate of vertices are $(h \pm a, k)$
- Coordinate of co vertices are $(h, b \pm k)$

Equation for Perimeter of Ellipse:

$$P = 2\pi\sqrt{\frac{a^2 + b^2}{2}}$$

6. Why I chose this Topic?

I chose to research Chandrayaan III's journey because of my love for space science and the universe which has transformed me as a person completely. I draw inspiration from various individuals the works of whom encourage me to explore the cosmos as well. This mission, to me, represents not only India's remarkable step forward in space exploration but a subtle opportunity to inspire the young, brilliant scientists of our future - to urge them to try their best to contribute to the ever-expanding frontier of cosmic knowledge. This paper is my humble contribution to this endeavor, and I aim to distinctly analyze the remarkable journey of Chandrayaan III and portray its significance in furthering our understanding of the universe.

7. Calculation and Orbital Equations:

Equation for Earth Maneuver and Lunar Maneuver were calculated by plotting points on desmos with Earth and Moon radius taking under consideration:

Radius of Earth= Re=6378 km
Radius of Moon=Rm=1737 km

Assumption: Earth and Moon are taken as perfect circle but in reality they are not perfect circles.
For Earth related orbits and equation, center is taken as center of earth (0,0).
For moon related orbits and equation, center is taken as center of moon (0,0).

Orbit distances are given in table under mission profile. Distance is taken from earth surface so we consider a point on circle as observation point.

1. Earth Maneuver 1:

Diameter of Earth and orbit distances added together gives length of major and minor axis.

2a= 2Re+2x where x is vertical orbital distance and Re is radius of earth.
2b= 2Re+2y where y is horizontal orbital distance and Re is radius of earth.

Equation for Earth Maneuver 1: $\frac{x^2}{(48148)^2} + \frac{y^2}{(6551)^2} = 1$

2. Earth Maneuver 2:

Diameter of Earth and orbit distances added together gives length of major and minor axis.

2a= 2Re+2x where x is vertical orbital distance and Re is radius of earth.
2b= 2Re+2y where y is horizontal orbital distance and Re is radius of earth.

Equation for earth Maneuver 2: $\frac{x^2}{(48981)^2} + \frac{y^2}{(6604)^2} = 1$

3. Earth Maneuver 3:

Diameter of Earth and orbit distances added together gives length of major and minor axis.
Center for this ellipse is not (0, 0) as it is moving toward moon, so to calculate major and minor axis we consider that there is shorter side from earth-a1, b1 and longer side from earth -a2,b2.
2a= a1+a2+2Re
2b=b1+b2+2Re

And Value of (h,k)is calculated which tell how much there is deviation from center(0,0).

Value of h=0 because k>>>>>h, so there is no change in vertical path.

h= a1-a (longer side-Half of major axis)
k=b1-b (longer side-Half of major axis)

Equation for Earth Maneuver 3: $\frac{(x-4898.5)^2}{(52879.5)^2} + \frac{(y)^2}{(6605)^2} = 1$

4. Earth Maneuver 4:

Diameter of Earth and orbit distances added together gives length of major and minor axis.
Center for this ellipse is not (0, 0) as it is moving toward moon, so to calculate major and minor axis we consider that there is shorter side from earth-a1, b1 and longer side from earth -a2,b2.

2a= a1+a2+2Re
2b=b1+2+2Re

And Value of (h,k)is calculated which tell how much there is deviation from center(0,0).
Value of h=0 because k>>>>>h, so there is no change in vertical path.

h= a1-a (longer side-Half of major axis)
k=b1-b (longer side-Half of major axis)

Equation for Earth Maneuver 4: $\frac{(x-14874)^2}{(62855)^2} + \frac{(y)^2}{(6800)^2} = 1$

5. Earth Maneuver 5:

Diameter of Earth and orbit distances added together gives length of major and minor axis.
Center for this ellipse is not (0, 0) as it is moving toward moon, so to calculate major and minor axis we consider that there is shorter side from earth-a1, b1 and longer side from earth -a2,b2.

2a= a1+a2+2Re
2b=b1+b2+2Re

And Value of (h,k)is calculated which tell how much there is deviation from center(0,0).

h= a1-a (longer side-Half of major axis)
k=b1-b (longer side-Half of major axis)
Value of h=0 because k>>>>>h, so there is no change in vertical path.

Equation for Earth Maneuver 5: $\frac{(x-43000)^2}{(90981)^2} + \frac{(y)^2}{(7505)^2} = 1$

6. Trans Lunar Injection:

Last Elliptical path is Trans lunar injection in which LMV3 leave earth's orbit and moon catches it with its gravitational force and orbits around it.

The path is half ellipse because after that it revolves around moon.

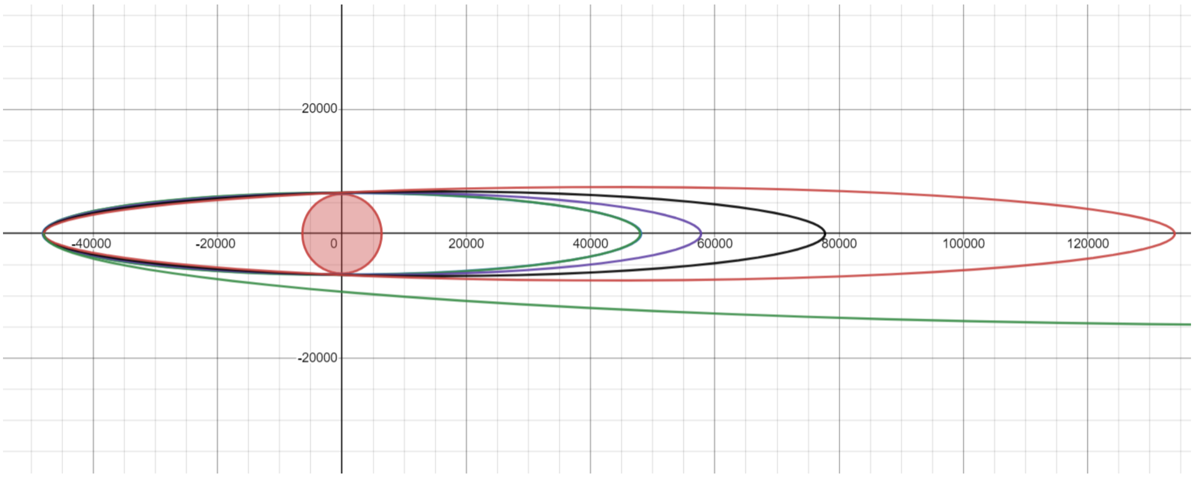
Diameter of Earth and orbit distances added together gives length of major and minor axis.
Center for this ellipse is not (0, 0) as it is moving toward moon, so to calculate major and minor axis we consider that there is shorter side from earth-a1, b1 and longer side from earth -a2,b2.

2a= a1+a2+2Re
2b=b1+b2+2Re

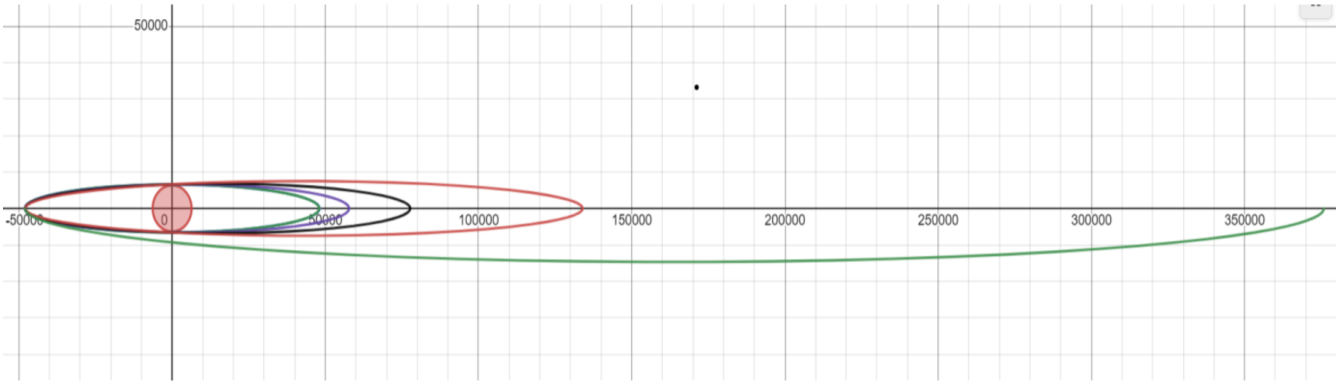
And Value of (h,k)is calculated which tell how much there is deviation from center(0,0).

h= a1-a (longer side-Half of major axis)
k=b1-b (longer side-Half of major axis)
Value of h=0 because k>>>>>h, so there is no change in vertical path.

Equation for Trans Lunar Injection: $\frac{(x-163942)^2}{(211923)^2} + \frac{(y)^2}{(14700)^2} = 1,$ {y>0}



- Shaded Red Circle: Earth, Equation for circumference of Earth= $x^2 + y^2 = (6378)^2$
- Blue ellipse: Earth Maneuver 1
- Green ellipse: Earth Maneuver 2
- Purple ellipse: Earth Maneuver 3
- Black ellipse: Earth Maneuver 4
- Red ellipse: Earth Maneuver 5



- Green half ellipse: Trans Lunar Injection

7. <u>Lunar Maneuver 1(Lunar orbit Insertion):</u>

Diameter of Moon and orbit distances added together gives length of major and minor axis.
Center is taken as center of moon for lunar maneuver.

Diameter of moon and orbit distances added together gives length of major and minor axis.
Center for this ellipse is not (0, 0) as it is moving toward moon, so to calculate major and minor axis we consider that there is shorter side from earth-a1, b1 and longer side from earth -a2,b2.

2a= a1+a2+2Rm ,Rm is radius of moon.
2b=b1+b2+2Rm ,Rm is radius of moon.

And Value of (h,k)is calculated which tell how much there is deviation from center(0,0).
Value of h=0 because k>>>>>h, so there is no change in vertical path.

h= a1-a (longer side-Half of major axis)
k=b1-b (longer side-Half of major axis)

2a= 2Rm+2x where x is vertical orbital distance and Rm is radius of moon.
2b= 2Rm+2y where y is horizontal orbital distance and Rm is radius of moon.

Equation for Lunar Maneuver 1: $\frac{x^2}{(4000)^2} + \frac{(y+8617)^2}{(12930)^2} = 1$

8. <u>Lunar Maneuver 2:</u>

Diameter of Moon and orbit distances added together gives length of major and minor axis.
Center is taken as center of moon for lunar maneuver.

Diameter of moon and orbit distances added together gives length of major and minor axis.
Center for this ellipse is not (0, 0) as it is moving toward moon, so to calculate major and minor axis we consider that there is shorter side from earth-a1, b1 and longer side from earth -a2,b2.

2a= a1+a2+2Rm ,Rm is radius of moon.
2b=b1+b2+2Rm ,Rm is radius of moon.

And Value of (h,k)is calculated which tell how much there is deviation from center(0,0).
Value of h=0 because k>>>>>h, so there is no change in vertical path.

h= a1-a (longer side-Half of major axis)
k=b1-b (longer side-Half of major axis)

Equation for Lunar Maneuver 2: $\frac{x^2}{(1900)^2} + \frac{(y+299)^2}{(4612)^2} = 1$

9. <u>Lunar Maneuver 3:</u>

Diameter of Moon and orbit distances added together gives length of major and minor axis.
Center is taken as center of moon for lunar maneuver.

Diameter of moon and orbit distances added together gives length of major and minor axis.
Center for this ellipse is not (0, 0) as it is moving toward moon, so to calculate major and minor axis we consider that there is shorter side from earth-a1, b1 and longer side from earth -a2,b2.

2a= a1+a2+2Rm ,Rm is radius of moon.
2b=b1+b2+2Rm ,Rm is radius of moon.

And Value of (h,k)is calculated which tell how much there is deviation from center(0,0).
Value of h=0 because k>>>>>h, so there is no change in vertical path.

h= a1-a (longer side-Half of major axis)
k=b1-b (longer side-Half of major axis)

Equation for Lunar Maneuver 2: $\boxed{\frac{x^2}{(1900)^2} + \frac{(y)^2}{(2544)^2} = 1}$

10. <u>Lunar Maneuver 4:</u>

Diameter of Moon and orbit distances added together gives length of major and minor axis.
Center is taken as center of moon for lunar maneuver.

Diameter of moon and orbit distances added together gives length of major and minor axis.
Center for this ellipse is not (0, 0) as it is moving toward moon, so to calculate major and minor axis we consider that there is shorter side from earth-a1, b1 and longer side from earth -a2,b2.

2a= a1+a2+2Rm ,Rm is radius of moon.
2b=b1+b2+2Rm ,Rm is radius of moon.

And Value of (h,k)is calculated which tell how much there is deviation from center(0,0).
Value of h=0 because k>>>>>h, so there is no change in vertical path.

h= a1-a (longer side-Half of major axis)
k=b1-b (longer side-Half of major axis)

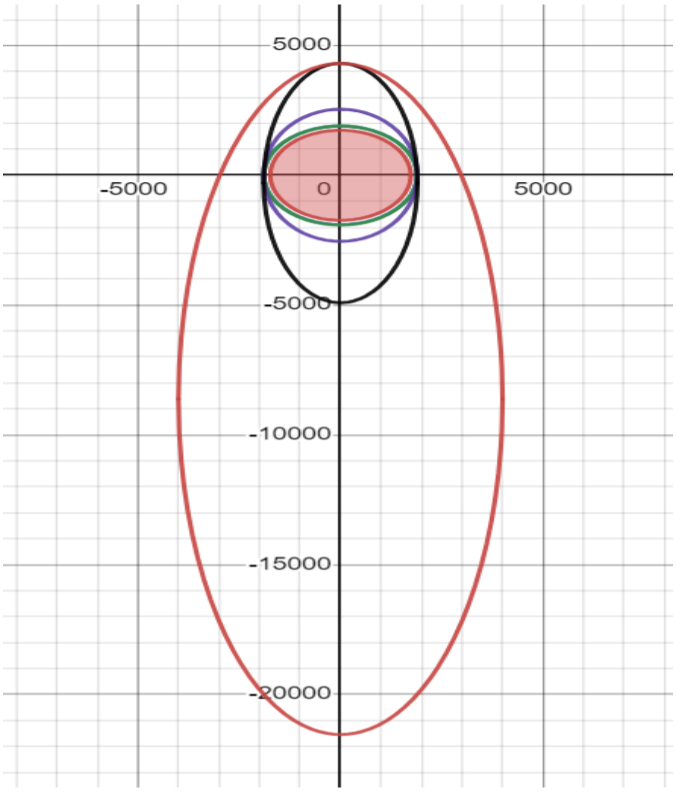
Equation for Lunar Maneuver 2: $\frac{x^2}{(1890)^2} + \frac{(y+7)^2}{(1907)^2} = 1$

11. <u>Lunar Maneuver 5:</u>

Diameter of moon and orbit distances added together gives length of major and minor axis.

2a= 2Rm+2x where x is vertical orbital distance and Rm is radius of moon.
2b= 2Rm+2y where y is horizontal orbital distance and Rm is radius of moon.

Equation for Lunar Maneuver 5: $\frac{x^2}{(1890)^2} + \frac{(y)^2}{(1900)^2} = 1$



- Shaded Red Circle: Moon,

Eqn for circumference of Moon
$x^2 + y^2 = (1737)^2$

- Red ellipse: Lunar Maneuver 1
- Black ellipse: Lunar Maneuver 2
- Purple ellipse: Lunar Maneuver 3
- Green ellipse: Lunar Maneuver 4
- Blue ellipse: Lunar Maneuver 5

12. Distance Travelled by LMV3 throughout journey:

Major and minor axis is calculated along with no. of revolution of orbit.

Stage and Sequence of LMV3	Major Axis(a)	Minor Axis(b)	Perimeter of Ellipse (in km)	Revolution	Total Distance (in km)
Earth bound maneuvers:1	48148	6551	3708878686	2	7417757373
Earth bound maneuvers:2	48981	6604	3837064576	6	23022387457
Earth bound maneuvers:3	52879.5	6605	4460853509	2	8921707017
Earth bound maneuvers:4	62855	6800	6278458820	5	31392294102
Earth bound maneuvers:5	90981	7505	13090808278	3	39272424834
Trans Lunar injection	211923	14700	35443014722	1	35443014722
Lunar bound maneuvers:1	4000	12930	287746168	1	287746168
Lunar bound maneuvers:2	1900	4612	39082267.12	10	390822671.2
Lunar bound maneuvers:3	1900	2544	15836668.04	38	601793385.4
Lunar bound maneuvers:4	1890	1907	11323476.45	45	509556440.2
Lunar bound maneuvers:5	1890	1900	11281616.3	51	575362431.2
				Total Distance=	1.47835E+11

Trans Lunar injection perimeter is taken half as it only covers half ellipse.

Total Distance Covered= 1.47835 X 10^{11} km.
Time taken= 31 days= 31*24=744 hours (15th July to 16th August)

Average Speed=$\frac{Total\ \text{Distance}}{Time\ Taken}$=1.83278 x$10^{11}$ / 744= 1.987 x 10^{8} km/hr.

8. Conclusion:

The purpose of doing this research paper is to study path of orbits, total distance travelled, average speed of LMV3. We employed concept of conic section- ellipse (elliptic orbit) as our path of LMV3. For this we have calculated various equation of ellipse for each maneuver. Our research paper is relevant in the field of astrophysics and mathematics for Chadrayaan-3. We are successfully in calculating 11 equations of orbits covered by LMV3. We have successful calculated total distance covered by KMV3 that is 1.47835 X 10^{11} km . From this data, we also got average speed of LMV3 for the whole journey, 1.987 x 10^{8} km/hr.

Concluding this research paper, by slogan given by honorable Prime minster of India Shri. Narendra Modi: " Jai Vigyan, Jai Anushandhan" which means victory over research is victory over science.

9. References:

https://en.wikipedia.org/wiki/Chandrayaan-3

https://www.isro.gov.in/Chandrayaan3.html

https://twitter.com/

https://nssdc.gsfc.nasa.gov/

https://indianexpress.com/

https://www.sciencedirect.com/

https://academic.oup.com/

https://www.wionews.com/

https://www.bbc.com/

10. Bibliography:

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- Currently studying in Mayo College Girls' School, Ajmer, in Class XII, pursuing Science Stream ISC curriculum
- President, Science Society - Contributed Immensely to the School Science Magazine - 'Quanta'. Participated in several Olympiads and brought Laurels in Numerous Science Quizzes. Handheld various activities in the Science Society for different classes.
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- Scored 98.0% in ICSE Board Examinations
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