सत्यमेव जयते
NITI Aayog

ATAL INNOVATION MISSION

SPACE MODULE LEVEL 1

Where Curiosity Opens Galaxies

Acknowledgements

The Space Curriculum aims to foster scientific curiosity and innovation among students of Classes VI–XII by aligning education with India's growing advancements in space science and technology. It emphasizes space related experiential learning to connect classroom concepts with real-world applications and strengthen critical thinking. This collaborative initiative is envisaged to inspire the next generation of scientists and innovators while strengthening space education in schools.

Advisory Creative Inputs

- **Shri Deepak Bagla,** Mission Director, AIM, NITI Aayog
- **Group Captain Shubhanshu Shukla,** IAF and Astronaut at ISRO
- **Dr. Amarendra P. Behera,** Joint Director, CIET
- **Ms. Deepali Upadhyay,** Program Lead, AIM, Niti Aayog

Value Adder, Curator and Co-ordinator

- **Dr. Srimathy Kesan,** Founder, CEO, Space Kidz India
- **Mr. Ratnesh Mishra,** President, Co-Founder IDYM Foundation (ISRO's registered Space tutor)
- **Mr. Shubham Gupta,** Innovation Lead, AIM, NITI Aayog
- **Ms. Arunima Thappa,** Young Professional, AIM, NITI Aayog
- **Mr. Suman Pandit,** Ex-Innovation Lead, AIM, NITI Aayog
- **Ms. Jaya Tare,** CEO, Newrizon Space, Ex-IAF Pilot

Content Inputs Team

- **Ms. Ridhi Jain,** Innovation Lead, AIM, NITI Aayog
- **Mr. Hrishikesh M P,** Young Professional, AIM, NITI Aayog
- **Ms. Maulika Kulkarni ,** Young Professional, AIM, NITI Aayog
- **Intel India Learning**
- **Links Foundation**
- **Dassault Systèms**
- **1M1B**
- **Space Tech Explorers**
- **Mr. Kiran Kumar H S,** Independent Management Consultant

Content Preparation Team

- **Mrs. Manvi Dhawan,** Space Expert, CTO, IDYM Foundation
- **Mr. Premprakash,** Technical Associate, Space Tutor, IDYM Foundation
- **Mr. Keshav Prabhu S K,** Research and Development, Analyst, Space Kidz India
- **Mr. Shrawan Yadav,** shrawantalks studio Editing Credits, IDYM Foundation
- **Maya Anthraper AP**
- **Dr. Javid Qadir Zarger**
- **Ms. Maithili Rane**
- **Ms. Kannu Darmwal**
- **Mr. Kunal V Charlewar**
- **Ms. Meenakshi Bhatia**
- **Mr. Kaysar Nizam**
- **Mr. Mohd Yaqoob Mir**
- **Dr. Himani Kohli**
- **Ms. Arati Tiwari**
- **Ms. Shilpa Nandurkar**
- **Mr. Akkapelly Ravi**
- **Mr. Rahul Shandilya**
- **Ms. Amrita Saxena**

Table of Content

Introduction to Space Science

01 What is Science?

Have you ever wondered why things fall down? Why is the sky blue? How does rain happen? Why can't we fly? Finding answers to questions like these is what science is all about.

Science is:

- **Asking questions about the world around you**
- **Observing things carefully**
- **Finding answers through experiment and discovery**

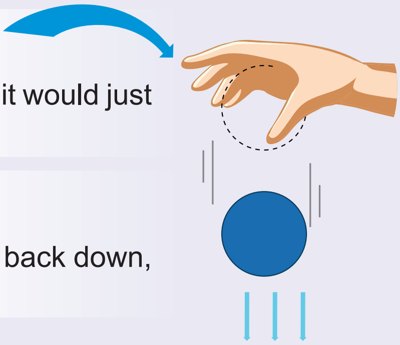
The Story of an Apple

Once, a boy named Isaac Newton was sitting under a tree. Suddenly, a fruit fell down. He thought: "Why did it fall down? Why didn't it go up?"

This simple question led to one of the most important discoveries in science - Gravity. This is the force that pulls everything toward Earth.

Did You Know?

What would happen if there was no gravity? Imagine throwing a ball into the air - it would just keep going up and up forever! Without gravity, we wouldn't stay on the ground.



Try This!

Take a pen or eraser and throw it up into the air. Watch what happens. It comes back down, right? This is science - observing things happening around you!

02 Science is Everywhere

Science is not just something you find in textbooks. Science happens everywhere:

• A ball falling → Science • A plant growing → Science • Cooking food → Science • Your phone working → Science

You are using science every single day without even realizing it!

Think About It

If science helps us understand Earth and everything on it, can we also understand the sky? Can we understand the stars, planets, and Moon?

Yes! And that study is called Space Science

03 What is Space Science?

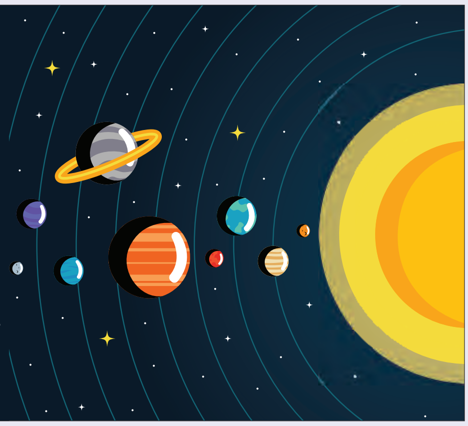
Space Science is the study of: • The sky and everything in it • Stars, planets, Moon, and Sun • The entire universe we live in

Space Science is the study of:

- The sky and everything in it
- Stars, planets, Moon, and Sun
- The entire universe we live in

Our Place in Space

Earth is our home, and it is not alone. Earth moves around the Sun. There are seven other planets that also move around the Sun. Together, all these planets and the Sun form our Solar System. But here's the amazing thing-there are billions of other stars out there, each with their own planets!



Did You Know?

There was a time when humans knew almost nothing about space. People had many questions:
• Is there air in space? • Is it completely dark? • Can rockets go there and come back safely? • Or will they be lost forever?

What People Believed Long Ago

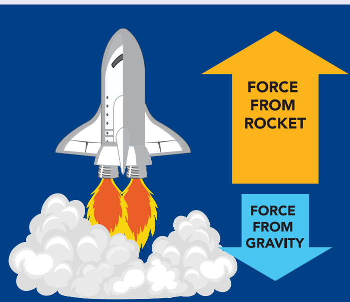
Before scientists began exploring space, many people feared it.
They thought: • Objects going into space might burn or disappear
• They might be lost forever • Earth's gravity would pull everything back immediately
Space was like a huge, unknown, and scary place!

04 The First Journey to Space

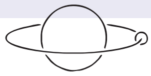
The Big Questions

When scientists decided to send the first satellite into space, they had many doubts:
• Will the rocket reach space? • Will the satellite stay there?
• Will it fall back to Earth? • Or will it disappear forever?

No one was 100% sure what would happen!



A Brilliant Idea: ORBIT



Then scientists had a breakthrough idea. They asked: "What if we throw something sideways with very high speed?"
Think about it this way: If you throw something horizontally (sideways), it will fall toward the ground. But what if you throw it so fast that by the time it falls, Earth's surface has curved away? Then it would keep falling but never actually hit the ground. It would keep going around Earth forever!
This is called an Orbit.
Understanding **Orbit**
Imagine you are swinging a stone tied to a rope in a circle. When you let go of the rope, the stone falls down. But while you keep swinging it, the stone keeps moving in a circle without falling.

A satellite works exactly like this! It is constantly falling toward Earth, but it is moving so fast sideways that it keeps missing Earth. So it falls around Earth instead of into it.

On October 4, 1957, something amazing happened. Scientists successfully launched the first satellite into space. It was called **Sputnik 1.**

The whole world was watching. Would it work? Would it stay in space?
And then - Beep... Beep... A signal came from space! This simple sound meant:
• The satellite is safe • It is moving in orbit • It is not lost
This was one of the greatest moments in human history!

What Scientists Learned

From this success, scientists understood something important:
• Objects CAN stay in space • With the right speed, they don't fall back to Earth • Space is not as dangerous as we feared • Humans could explore space!

05 Can Living Things Survive in Space?

The Big Questions

Scientists had proved that satellites could stay in space.
But one huge question remained:
Can living beings survive in space?
To find out, scientists decided to send a living creature into space.
They sent a dog named Laika.

On November 3, 1957, Laika became the first living being to orbit Earth. Laika's mission taught scientists something very important:

• Living beings can survive the launch into space • Life can survive space conditions only for a limited time with proper life-support systems

Laika's brave journey opened the door for humans to explore space!

Think About It

From one dog's journey, scientists learned that space exploration was possible for living creatures. Soon after, humans followed!

06 Why Should We Care About Space?

Space science might sound like something far away from your daily life. But it actually affects you every single day! "Every time someone uses Google Maps to find a pizza shop, or watches a live cricket match on TV, a satellite is working for them - from 36,000 kilometers away in space!"

Without space science and satellites, modern life as we know it would stop. No GPS, no weather forecasts, no TV broadcast

Saving Lives: The Cyclone Story

In 1999, a cyclone hit Odisha. At that time, India didn't have very good satellite data. Thousands of people lost their lives because they couldn't be warned in time.
But look at what changed! In 2023, when much bigger cyclones hit India, scientists used satellite data to evacuate millions of people to safety. **Space science didn't just save money—it saved families and lives.**

Feeding the Nation: Precision Farming

Indian satellites help farmers in amazing ways. They tell farmers:

- When to plant seeds
- Where the soil is healthy
- Which areas need water
- Which fields need fertilizer

This helps increase India's food production. In fact,
India is becoming a "Food Superpower" thanks to space science!

Did You Know?

Without satellites watching Earth, we wouldn't know about weather patterns, natural disasters, or even where to find resources. Space science is connected to your life in ways you never imagined!

07 India's Journey to Space

India's space story is one of the most inspiring stories of human achievement. It started not with billions of dollars, but with dreams and determination.

A Small Beginning (1962)

A visionary scientist named Dr. Vikram Sarabhai had a bold idea. He believed that India should build its own space program. But India faced limited resources and many challenges at that time, and some people doubted the idea.

Dr. Sarabhai replied: "If we are to play a meaningful role nationally and in the community of nations, we must be second to none in the application of advanced technologies." He didn't want rockets for war. He wanted them for education, weather forecasting, and communication.

The Indian government listened to his dream. In 1962, India's space program started. It was called INCOSPAR (Indian National Committee for Space Research).

The Churh Lab: A Unique Office

Our first office wasn't a fancy building with computers and laboratories. It was the St. Mary Magdalene Church in Thumba, Kerala!

Why a church? Because it was located on the Magnetic Equator—a perfect location for launching rockets into space. The Bishop gave the church to the scientists, and the prayer room became a laboratory. Scientists worked on space technology in the same room where people came to pray!

This shows us that great achievements don't always need great resources. They need great ideas and determination.

August 15, 1969: India's Space Independence

On Independence Day 1969, while the world celebrated the first Moon landing (Apollo 11), India officially created ISRO (ISRO).

India chose Independence Day to tell the world: "We are now independent in space too!”

08 Building a Ladder to Space

ISRO didn't just build one rocket. It built a series of rockets, each one stronger and more capable than the last. Like climbing a ladder, each step helped India reach higher.

Aryabhata (1975): Our First Satellite

India's first satellite was Aryabhata. It was named after the ancient Indian mathematician.

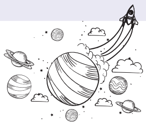
Here's something amazing: The satellite was so heavy and sensitive that scientists moved it using a bullock cart! Why? Because the cart's rubber tires and slow speed provided the smoothest ride. The satellite could be damaged by even small vibrations.

The satellite was launched using a Russian rocket, but the "brain" of the satellite, the technology that made it work was 100% Indian.

The SLV Era (1980): Made in India

By 1980, India built its first homemade rocket called SLV (Satellite Launch Vehicle). This was a huge moment! It proved that India didn't need to depend on other countries. We could launch our own satellites from our own soil. The hero behind this achievement was Dr. APJ Abdul Kalam, who would later become India's President. He worked day and night to make this dream real.

Did You Know?



In 1979, Dr. Kalam's first big launch failed. The rocket SLV-3 crashed into the Bay of Bengal. He was heartbroken. But his mentor, Satish Dhawan, took the blame and encouraged him. One year later, they succeeded!

This teaches us an important lesson: Failure in science is not the end. It is just data that tells you how to succeed next time.

PSLV: The Workhorse

India's most famous and reliable rocket is the PSLV (Polar Satellite Launch Vehicle). It is so reliable that other countries trust it to launch their satellites! In 2017, a single PSLV rocket did something incredible. It launched 104 satellites in one mission! This was a world record.

Think of PSLV as a high-tech school bus for satellites. It can carry many satellites and deliver them safely to space.

GSLV: The Heavy Lifter (Bahubali)

For heavier missions, India built an even more powerful rocket called GSLV (Geosynchronous Satellite Launch Vehicle). We call it "Bahubali" because it is our strongest rocket. What makes GSLV special? It uses a Cryogenic Engine. This is an engine that uses fuel kept at a super-cold temperature of −250°C. Building and using such cold engines is very difficult and requires advanced technology.

This is the rocket that carries India's missions to the Moon and Mars!

Think About It

India built all these rockets from scratch. No other country gave us the technology. We invented it ourselves. This is true Atmanirbharta (self-reliance).

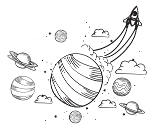
09 Reaching for the Moon and Mars

Chandrayaan-1 (2008): Water on the Moon!

For hundreds of years, people thought the Moon was just a dry, dusty desert with no water. But India changed this! In 2008, India sent a mission called Chandrayaan-1 to the Moon. This mission made a discovery that shocked the world. Scientists found water molecules (ice) on the Moon! This was huge! If there is water on the Moon, astronauts could use it in the future. It could help humans live on the Moon.

Think About It

This discovery was so important that it changed how the entire world thought about the Moon. Chandrayaan-1 is remembered as one of India's greatest scientific achievements.



Mangalyaan (2013): Mars on the First Try

In 2013, India did something that many countries had attempted but not all succeeded on their first attempt. India sent a spacecraft to Mars and reached it successfully on the first attempt. This mission was called Mangalyaan (Mars Orbiter Mission).

And here's the incredible part: It cost only $74 million. Do you know how much the Hollywood movie Interstellar cost? $165 million! India reached Mars for less money than it took to make a movie!

Many countries had failed to reach Mars. But India succeeded on its very first try. This showed the world that India is a master of space exploration.

Chandrayaan-3 (2023): Landing at the South Pole

In 2023, India achieved another first. Chandrayaan-3 successfully landed a spacecraft near the South Pole of the Moon. Why is this so difficult? The lunar South Pole is the toughest place to land a spacecraft. It is dark, filled with deep craters, and extremely cold. Landing there requires amazing precision and advanced technology.

India became the first nation in the world to accomplish this feat. This victory belongs to every Indian!

10 Space Technology for Everyone

Education: EDUSAT

Dr. Vikram Sarabhai always believed that space technology should help everyone, not just rich people. Following this idea, India launched EDUSAT, the world's first satellite dedicated entirely to education.

EDUSAT connected schools in remote villages to teachers in big cities through satellite television. Children in villages far from cities could now learn from excellent teachers. Space technology was bringing education to everyone!

Navigation: NavIC

India also created its own GPS system called NavIC (Navigation with Indian Constellation).

NavIC is like having your own compass in the sky. It helps:

- Indian fishermen find fish in the deep sea
- People navigate using a map on their phones
- The government keep our borders safe

India doesn't depend on other countries' GPS systems anymore!

Mapping: Bhuvan

ISRO created Bhuvan, which is India's version of "Google Earth."

Farmers use Bhuvan to:

- Check their soil's health
- Plan when to plant crops
- See which areas need water

The government uses it to manage water resources and plan development. Space science is helping farmers grow more food!

Think About

these technologies came from space science. They show that space is not just for astronauts. It is for farmers, fishermen, students, and everyone!

11 Why India's Space Program is Special

We Do Big Things with Small Budgets

The whole world is amazed by India's space program. Why? Because we achieve world-class results at the lowest cost.

Our scientists are experts at finding creative solutions. We use resources wisely. We prove that big achievements don't always need big budgets.

We Made Ourselves Independent

In the 1960s, many countries refused to share space technology with India. They said, "You are too poor. You can't build rockets."

But India didn't give up. We built our own rockets, our own satellites, and our own engines. Now, we don't depend on anyone!

This is Atmanirbharta -self-reliance. India showed the world that we can do anything we set our minds to.

The World Trusts Indian Rockets

Today, countries like the USA, UK, France, and Singapore pay ISRO to launch their satellites!

Why do they trust us? Because our rockets are reliable. They work. Other countries know that when they give us a satellite, it will reach space safely.

ISRO has become the world's launchpad for space missions!

12 Your Future in Space

Space science is not just history. It is the future! And that future might include you.

Gaganyaan: Indians in Space

Very soon, India will send its first human astronauts into space through their own rockets. This mission is called Gaganyaan. Imagine this: An Indian rocket, built by Indians, launching from Indian soil, carrying Indian astronauts to space. This is the ultimate "Make in India" project!

One of those astronauts could be someone like you!

Space Mining

Did you know that Earth is running out of precious metals? Gold, lithium (used in phone batteries), platinum these resources are becoming scarce.

But there's good news! Some asteroids floating in space contain enough minerals to make every person on Earth a billionaire! In the future, engineers and scientists will design space robots that can mine these asteroids and bring resources back to Earth. This could solve Earth's resource problems.

Do you think you could be a space mining engineer?

Space Police: Protecting Our Planet

As more and more satellites launch, there's a problem. Old satellites and rocket parts are floating around Earth as "space junk." If this junk crashes into working satellites or spacecraft, it could cause disasters. We need space police scientists and engineers who track space junk and clean it up.

This might sound like a job from a science fiction movie, but it's a real job that will be very important in the future!

Think About

The future of space has many careers that haven't been invented yet. Your job in space might not even have a name today. But if you study science, technology, and math today, you could create that future! everyone!

Conclusion

We started this journey asking simple questions: Why do things fall? Why is the sky blue? Why can't we fly? From these simple questions, humans discovered gravity, built rockets, and reached space. From a church lab in Kerala to the Moon and Mars, India's space journey is a story of courage, creativity, and determination.

And this story is not finished. You are part of the next chapter.

The stars are waiting. Are you ready?

Key Takeaways

1. Science is about asking questions and finding answers through observation
2. Space science helps us understand the universe
3. With the right speed and direction, objects can orbit Earth
4. Living beings can survive in space
5. Space technology affects our daily lives in many ways
6. India built its own space program through determination and innovation
7. ISRO is now one of the world's leading space organizations
8. Space science creates opportunities and careers for the future
9. India's achievements prove that big dreams need big determination, not big budgets
10. The future of space exploration might include you!

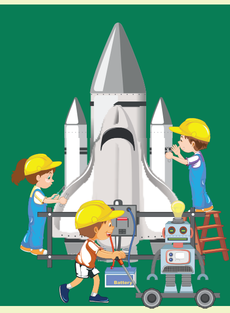
01 Launch

From Countdown to Orbit Insertion

1.1 Pre-launch and Countdown

To simulate a real rocket launch countdown procedure and understand the scientific importance of system checks before liftoff.

Objective



a. **To understand why rockets require pre-launch system verification.**
b. **To identify major systems involved in a rocket launch.**
c. **To learn the importance of structured communication.**
d. **To experience coordination similar to Mission Control.**
e. **To develop teamwork and decision-making skills.**

Scientific Foundation

Imagine standing near a rocket that is filled with fuel, powerful engines, and advanced computers. Would you press the launch button without checking anything? Of course not. A rocket is not a simple machine.

It is a collection of many systems working together simultaneously.

- Inside a rocket are:
- Engines that produce thrust
- Fuel tanks storing propellant
- Navigation systems that control direction
- Communication systems that send signals
- Electrical systems that power onboard computers

Each system has a specific job. But here is the important part: If even one system is not ready, the rocket cannot launch safely.

What Is a Countdown Really For?

When we hear: “10… 9… 8…”It sounds exciting. But scientifically, a countdown is not for excitement. It is for verification.Before launch, engineers must confirm that every system is working properly. Mission Control calls out each system one by one: “Propulsion?”“Navigation?”“Communication?” “Safety?”Each team checks live data from sensors measuring: Pressure, Temperature, Fuel flow, Electrical power, Signal strength.

If everything is within safe limits, the system reports: **“GO.”** If something is abnormal, the system reports: **“NO GO.”** And the launch is paused.

Rockets work in extreme conditions like high temperature, pressure, and speed, where even a small mistake can cause failure. That is why scientists carefully check every system before launch. The countdown is not just exciting it ensures that engines, fuel, navigation, and communication systems are all ready at the right time. This process depends on proper timing, continuous monitoring, and teamwork, making sure everything works together perfectly. Through this activity, students understand that real rocket launches rely on precision, coordination, and careful planning.

Real-World Connection

ISRO follows strict countdown procedures before launching rockets such as PSLV and GSLV. Similarly, NASA conducts detailed system checks and launch readiness reviews before every mission. Only after all systems report "GO" does the final ignition sequence begin.

Pre-Activity Engagement

Puzzle / Thought Experiment

If 6 systems say "GO" and 1 system says "NO GO,"
Should the rocket be launched? Why or why not?

The countdown has already started…
Should the launch be stopped at the last second if a problem is detected?

Quick Demonstration (30–60 sec)

Inflate a balloon and release it without tying

Ask students: "What happened?"

The balloon moves randomly and uncontrollably

"If a rocket's control or system fails, it can behave in a similar uncontrolled way."

Lets start with the activity

Materials Required

1) Printed system cards (Propulsion, Navigation, Communication, etc.)
2) Countdown cards (T – 60, T – 30, T – 10, etc.)
3) Stopwatch
4) Whistle or bell
5) Role badges (optional)

Working Principle

This activity simulates real launch verification.

1. Each student represents one rocket system.
2. The Mission Director calls out each system.
3. The system officer responds with "GO" or "NO GO."
4. Launch proceeds only if all systems confirm readiness.

Procedure

Step 1: Assign Roles
Assign students the following roles:
1. Mission Director 2. Propulsion Officer 3. Fuel Systems Officer 4. Navigation Officer 5. Communication Officer 6. Safety Officer 7. Weather Officer

Step 2: Prepare Countdown
Arrange students in front like a Mission Control panel.

Step 3: Conduct System Checks
Mission Director calls: "Propulsion?" Response: "Propulsion – GO!"
Repeat for all systems. Optional: Introduce one "NO GO" scenario to simulate launch hold.

Step 4: Final Countdown
Mission Director announces: "T-10 seconds…"
Students count together. At zero, announce: "Liftoff!"

Self-Assessment Trivia

1. **What is the main purpose of a countdown?**
   A. Excitement B. System verification C. Decoration
2. **What does "NO GO" mean?**
   A. Everything is fine B. A problem is detected C. Launch faster
3. **A rocket can launch safely without checking systems** A. True B. False
4. **All systems must confirm readiness before launch** A. True B. False

Thinking Questions

1. What could happen if the communication system fails?
2. Which system do you think is the most important and why?

Observations

Students should observe:
- Importance of clear communication.
- Role of each system in mission success.
- How one "NO GO" stops the entire process.
- Structured sequence improves coordination.

Analysis and Conclusion

The roleplay shows that rocket launches depend on multiple systems working together seamlessly through strict safety checks that reduce the chance of failure. Clear communication discipline prevents confusion during critical operations, while double-checking every detail before taking action remains essential in high-risk environments.

The countdown sequence serves as a scientifically structured safety procedure that ensures all systems are fully prepared and verified before the final liftoff. This strategic synchronization effectively demonstrates the core principles of mission control and flight safety.

Did You Know?

Rocket launches can be aborted even seconds before liftoff for safety.

Where Else Do We See This Science?

- Pilots check all aircraft systems before take-off to ensure a safe flight
- Doctors check patient vitals and equipment before surgery
- Factories inspect machines and systems before starting production
- Race car drivers check tyres, engine, and fuel before a race

Precautions & Safety

⚠ Maintain discipline during roleplay.
⚠ Avoid excessive shouting.
⚠ Follow instructions clearly.
⚠ Teacher supervision required.

Additional Links

(Launch of LVM3)
https://www.youtube.com/live/q2ueCg9bvvQ?si=gOZ-QY8RLvNhZofB

(Lift of Atlas V)
https://youtu.be/00fXmv9xpOg?si=zBiKftBaigKoydee

Answer: Self-Assessment 1. B 2. B 3. B 4. A

01 Launch

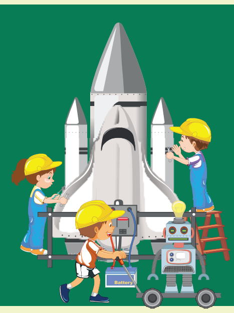
From Countdown to Orbit Insertion

1.2 Water Rocket Launch

To design, build, and launch a hydro rocket and understand the basic principles of rocket propulsion using water and air pressure.

Objective

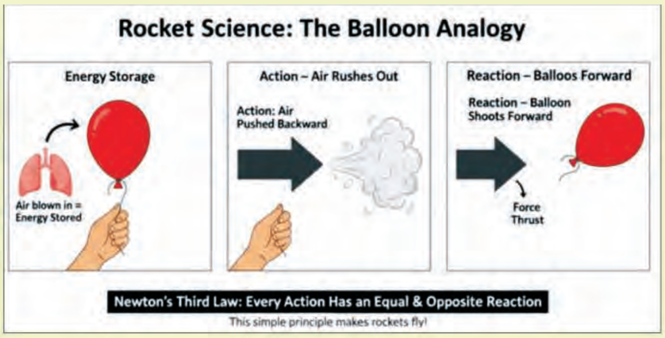
a. **To understand Newton's Third Law of Motion through a practical activity.**
b. **To learn how thrust is generated in rockets.**
c. **To explore the role of pressure in motion.**
d. **To study the effect of mass and design on rocket height.**
e. **To develop teamwork and observation skills.**

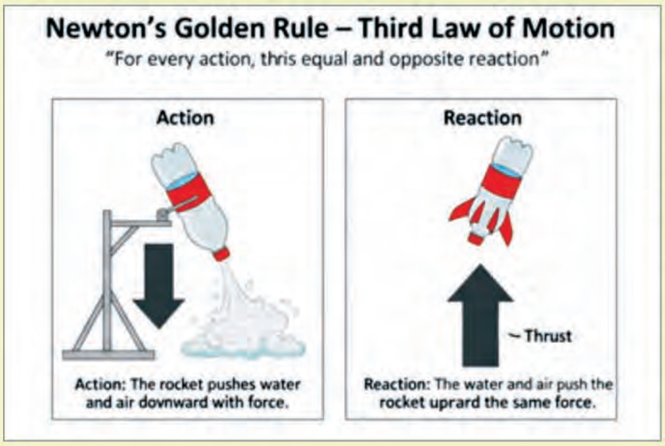


Scientific Foundation

1. Introduction - The Balloon Analogy

Rocket science may sound difficult, but the idea behind it is very simple. When we blow air into a balloon, energy is stored inside it. If the balloon is released without tying its mouth, the air rushes out from the back, and the balloon shoots forward. This happens because the air moving backward pushes the balloon forward. This simple balloon experiment explains the basic secret of how rockets fly.





2. Newton's Golden Rule – Third Law of Motion

Scientist **Sir Isaac Newton** gave an important law of motion: **"For every action, there is an equal and opposite reaction."**

- **Action:** The rocket pushes water and air downward with force.
- **Reaction:** The water and air push the rocket upward with the same force.

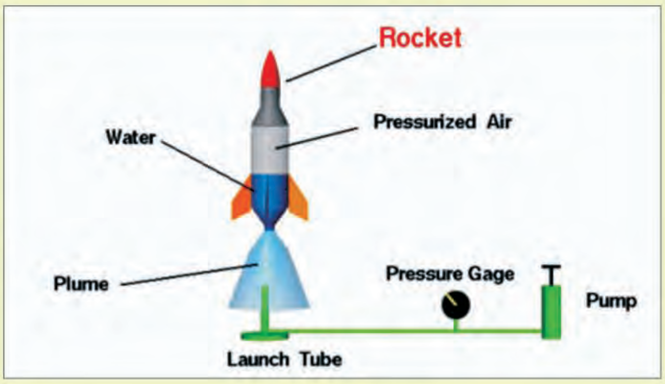
The upward force that lifts the rocket is called **thrust.**

3. What Is a Hydro Rocket?

A hydro rocket is a simple type of rocket that does not use fire or burning fuel.

- **Fuel:** Water
- **Energy Source:** Compressed air

When air is pumped into the bottle, it gets compressed like a spring. When the cork is released, the compressed air pushes the water out very fast, and the rocket moves upward.



Real-World Connection

Around the world, space agencies like ISRO, NASA, China's CNSA, Japan's JAXA, and Russia's Roscosmos use the same action–reaction principle in their rockets. For example, rockets like PSLV, Long March, Soyuz, and H-IIA burn fuel to produce high-speed exhaust gases that are pushed downward, which in turn pushes the rocket upward. This is exactly the same principle demonstrated by a water rocket, where water is pushed downward to lift the rocket upward. The hydro rocket is a simple model that demonstrates the same physics used in real space missions.

Pre-Activity Engagement

Estimation Challenge

1. **How high do you think a water rocket can go?**
   A. 5–10 meters B. 20–50 meters C. 100+ meters
2. **What do you think pushes the rocket upward?**
   A. Water B. Air pressure C. Fire

Quick Demonstration (30–60 sec)

- Take a balloon and inflate it Ask students: "What is stored inside the balloon?"
 Air under pressure -Release it , "What happens?"
Air rushes out and balloon moves
- Connect:
"This is the same principle used in a water rocket"

Puzzle / Thought Experiment

If the bottle is filled completely with water (no air inside), will the rocket fly higher, lower, or not at all? Why? What will happen if there is air pressure but no water inside?
Will the rocket still launch effectively?

Lets start with the activity

Materials Required

1) 1-2 litre plastic bottle
2) Cardboard or foam sheet (for fins)
3) Strong adhesive tape
4) Rubber cork with air valve
5) Bicycle pump/hand pump
6) Water
7) Paper (for nose cone)
8) Safety goggles
9) Measuring tape

Working Principle

The hydro rocket works on the principle of compressed air expansion.
When air is pumped into the bottle, pressure builds up inside. This pressure stores energy. When the cork is released:

1. Compressed air expands rapidly.
2. Water is forced out at high speed.
3. Downward water motion creates upward thrust.
4. The rocket accelerates upward.

A proper balance between water quantity and air pressure gives maximum height.

(Water Rocket Launch)
https://youtube.com/shorts/_PEsfMlcvsQ?si=6vjFuhUoFXqkXw_V

Procedure

1

Step 1: Making the Rocket Body

- The bottle is turned upside down so that the bottom becomes the top of the rocket. This shape helps the rocket fly smoothly.

2

Step 2: Making the Nose Cone

- A sharp cone is made using a file folder or chart paper. A small amount of clay is placed inside the tip of the cone and then taped securely to the top of the bottle.
- The sharp shape reduces air resistance, and the added weight improves balance.

Step 3: Making the Fins
- Three or four triangular fins are cut and taped evenly near the bottle mouth. The fins help keep the rocket straight during flight

Step 4: Fill Water
- Fill approximately one-third of the bottle with water.

Step 5: Setup Launcher
- Insert the cork tightly into the bottle opening.
- Connect the air pump securely.

Step 6: Launch
- Move to an open ground area.
- Ensure all students stand at a safe distance.
- Wear safety goggles.
- Pump air slowly to build pressure.
- Countdown and release.

Self-Assessment Trivia

1. **What is the main force that pushes the water rocket upward?**
   A. Gravity B. Air pressure C. Magnetism
2. **Why is water used in a hydro rocket?**
   A. To increase weight B. To help create thrust when pushed out C. Just for cooling
3. **More air pressure can increase rocket height** A. True B. False
4. **Fins are used to make the rocket look good only** A. True B. False

Thinking Questions

1. Why is only one-third of the bottle filled with water?
2. What will happen if fins are not attached to the rocket?

Observations

Students should record:
- Approximate height reached________________
- Whether the rocket flew straight or tilted______
- Effect of changing water level_______________
- Effect of fin size and alignment_____________
- Duration of flight________________________

Observation	Result Scientific	Reason
Flight path	The rocket moved straight upward	Fins helped maintain stability
Speed	The rocket moved very fast	Sharp nose reduced air resistance
Height	The rocket reached a good height	Strong downward water force created thrust

Analysis and Conclusion

Through the experiment, students observe that the rocket rises due to action-reaction forces as described by Newton's Third Law. Increasing internal air pressure directly increases thrust, while adding too much water increases weight and reduces the maximum altitude. Proper fin alignment ensures flight stability, and a streamlined design minimizes drag to help the rocket reach greater heights.This hydro rocket successfully demonstrates how thrust is generated to overcome gravity using basic physics principles. By balancing pressure, fuel mass, and aerodynamics, the experiment provides a clear and practical validation of rocket engineering.

Did You Know?

Rocket engines can get hotter than molten lava

Where Else Do We See This Science?

- Fireworks rockets move upward when gases are pushed downward at high speed
- Jet engines produce thrust by pushing exhaust gases backward to move forward
- Garden sprinklers rotate when water is forced out in the opposite direction
- Space rockets generate thrust by expelling gases to overcome gravity and reach orbit

Precautions & Safety

⚠ Always launch in open ground.
⚠ Never stand above or near the rocket during pumping.
⚠ Wear safety goggles at all times.
⚠ Do not over-pump beyond safe limits.
⚠ Ensure cork is tightly secured before launch.
⚠ Perform only under teacher supervision

Additional Links

(India's first private rocket launch)
https://youtu.be/g_jh-LDSjB8

(Slow Motion Liftoff of NASA's Artemis)
https://youtu.be/aWCCNYJV3Z

(Water bottle rocket)
https://youtu.be/ii6D1R6IXVA

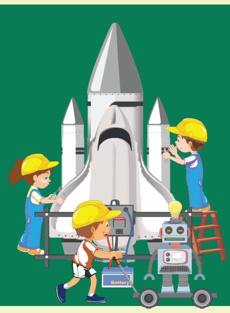
Answer: Pre-Activity Engagement 1. C 2. B Self-Assessment 1. B 2. B 3. A 4. B

1.3 Wind Resistance Demonstration

To study how wind resistance changes with speed, surface area, and material, and how it affects motion and safe landing.

Objective

a. **To understand the concept of air resistance (drag).**
b. **To observe how speed affects resistance force.**
c. **To visualize pressure differences created by moving air.**
d. **To relate wind resistance to rocket design.**
e. **To develop observation and analytical skills.**

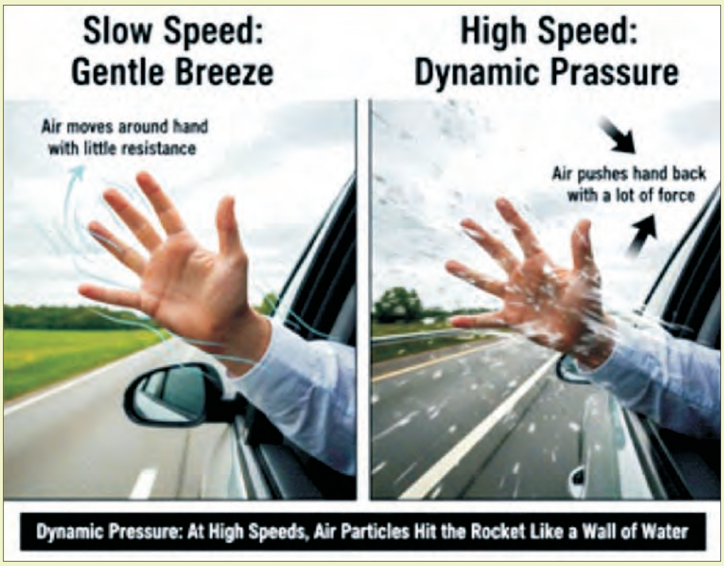


Scientific Foundation

Have you ever wondered why a rocket needs so much power to go up? Or why its nose is pointed? Let's unlock the real secret!

1. Air: An "Invisible Wall"

Air isn't just for breathing; when we move fast, it acts like a solid wall. Example: Stick your hand out of a moving car window. At slow speeds, you feel a gentle breeze, but at high speeds, the air pushes your hand back with significant force. Rocket Science: Air is made of trillions of tiny particles. When a rocket moves super fast, these particles slam into it like a wall of water. This pressure is called Dynamic Pressure.

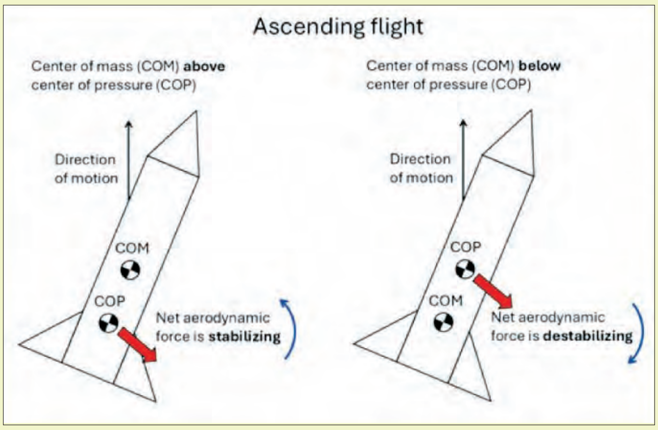


Dynamic Pressure: At High Speeds, Air Particles Hit the Rocket Like a Wall of Water

2. Aerodynamics: How a Rocket Fights Air

Aerodynamics is the study of how air interacts with objects. For a rocket, air does two main things:

1. Drag (The Speed Breaker): Air tries to slow the rocket down.
2. Stability (The Balance): Air helps keep the rocket flying straight.



Golden Rule: If the Fins are in the back and the Fuel/Weight is in the front, the rocket will fly as straight as an arrow!

3. How Does a Rocket Fly Straight? (Rocket Stability)

To prevent a rocket from crashing, two specific points must be perfectly balanced:

- **COM (Center of Mass):** The rocket's 'Weight Point' (where all the weight is balanced). This must always be in the front.
- **COP (Center of Pressure):** The 'Air Push Point' (where the air pushes the hardest). This must always be in the back.

4. Nose Cone and Shape: Slicing Through the Air

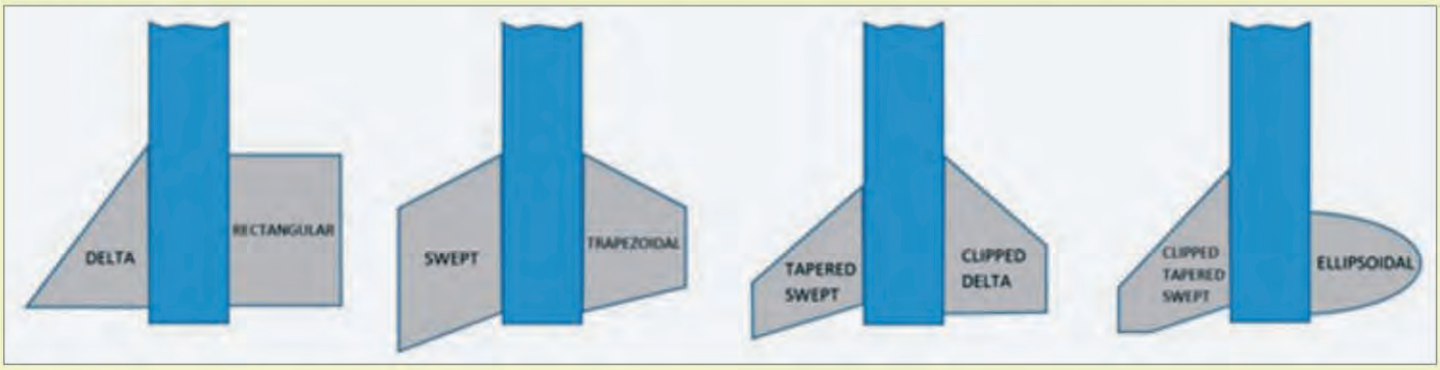
Why does a rocket have such a specific shape?

- **Pointed Shape:** This 'slices' through the air, allowing the air to flow smoothly around the sides. This reduces drag and saves fuel.

Flat Shape: If a rocket had a flat front, the air would crash into it, creating messy air (Turbulence) and slowing the rocket down.

5. The Magic of Fins: Small Wings, Big Job

Fins are an "Automatic Balance System" for the rocket.Just like a kite's tail keeps it from spinning, fins prevent the rocket from flipping over.If the rocket starts to tilt slightly in the air, the air pushes on the fins, forcing the rocket back onto a straight path.



6. Max-Q: The Rocket's Greatest Test

During launch, there is a specific moment when the rocket experiences the highest level of "Stress." This is called Max-Q.Think of it like this:

1. Phase 1: Near the ground, the air is very thick. As the rocket's speed increases, the air pressure starts to build up quickly.
2. Phase 2 (Max-Q): The rocket's speed is incredibly high, and the air is still thick enough to push back with maximum strength. At this moment, the rocket feels like it might be "Crushed" by the wind!
3. Phase 3: The rocket climbs higher, where the air becomes very thin. There are fewer particles now, so the pressure drops, and the rocket is safe.

Real-World Connection

Real rockets like PSLV, Falcon 9, and Long March are designed with pointed shapes to reduce air resistance and systems to maintain stability. During launch, engineers closely monitor **Max-Q**, where the rocket faces maximum air pressure, and adjust engine power to keep the rocket safe.

Wind resistance plays a major role during the initial phase of rocket ascent for space agencies.

Pre-Activity Engagement

● Estimation Challenge

1. Which shape do you think faces more air resistance (drag)?

A. Flat surface B. Round cylinder C. Pointed cone

2. If speed increases, what happens to air resistance?

A. Decreases B. Stays same C. Increases a lot

● Puzzle / Thought Experiment

Why do rockets, airplanes, and even birds have pointed or curved shapes instead of flat fronts? Imagine you are running fast:Which feels harder?

- Running with your hand flat facing air
- Running with your hand pointed forward Why?

● Quick Demonstration (30–60 sec)

Ask students to do this:

- Hold their hand flat and move it quickly through air
- Then make a pointed shape with fingers and move again

Ask:"What did you feel?" Flat shape feels more resistance Pointed shape moves more easily

Connect: "This is exactly why rockets are designed with pointed noses"

Lets start with the activity

Activity 1: Wind resistance Demo

Materials Required

1) Electric fan
2) Paper tubes (different diameters)
3) Flat sheet of paper
4) Conical paper model
5) Tape
6) Stand or support

Working Principle

This experiment shows how air flows around moving things, like in fluid dynamics. It proves that drag the force slowing you down, depends on how big the front of the object looks (its flat area facing the wind) and how fast it's going (speed squared). By changing the shape, we guide the air smoothly around it instead of letting it pile up in front and push back hard.

Procedure

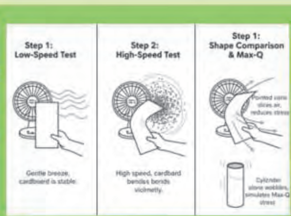
1

Step 1: The Low-Speed Test

- Place the Flat Cardboard in front of the fan on Level 1.
- Observe how the cardboard stays relatively still or vibrates only slightly.

Step 2: The Acceleration Phase

- Turn the fan to Level 3 (High Speed). Watch as the cardboard bends violently or is pushed backward. This represents the rocket gaining speed while still in the thick lower atmosphere.



2

3

Step 3: Shape Comparison

Replace the flat cardboard with the Cylindrical Tube. Notice it handles the wind better but still shakes.Now, place the Paper Cone on top of the cylinder. Observe how the air "splits" and flows around the cone smoothly. This is why rockets have pointed noses!

Step 4: Simulating Max-Q Stress

Take the cylindrical tube (without the cone) and hold it in front of the high-speed fan. Notice the "wobble." This wobble represents the vibration and stress a rocket feels at Max-Q. Now, put the cone on and see how the wobble disappears.

4

Activity 2: The Great Parachute Drop

To investigate how surface area and material type affect **Drag Force** and landing safety.

Materials Required

1) Lightweight Plastic (Trash bag), Cotton Cloth, Tissue Paper.
2) Strong string (nylon or cotton).
3) Measuring tape & Stopwatch.
4) Payload: A small nut, bolt, or a large eraser (approx. 20g).

Procedure

Step 1: Prototype Construction
Cut each material into an equal-sized octagon or circle (e.g., 30 cm diameter).Punch 8 holes around the edges and tie strings of equal length (e.g., 40 cm).Attach the other ends of the strings to your payload.

Step 2: The Drop Test
Drop the parachutes one by one from a fixed height (at least 2–3 meters).Use a stopwatch to record the Descent Time (from release to hitting the ground).Repeat 3 times for each material to get an average.

Step 3: Calculating Velocity
- Use the simple formula: $Speed = \frac{Distance}{Time}$
- The parachute with the **longest time** has the **highest Drag**.

Step 4: Variable Testing (Weight & Size)
- **Challenge:** Double the weight of the payload. Observe if the parachute still provides a "soft landing."
- **Challenge:** Cut a small hole (spill hole) in the very center of the parachute. Does it fall straighter now? (Answer: Yes, it reduces wobbling).

Self-Assessment Trivia

1. What is drag?
A. Force that pushes forward B. Air resistance that slows motion C. Heat energy

2. Which shape reduces drag the most?
A. Flat B. Square C. Cone

3. Higher speed increases air resistance A. True B. False

4. Shape of an object does not affect motion in air A. True B. False

Thinking Questions

1. Why do rockets face maximum stress at high speed in the lower atmosphere?
2. How does a cone shape help reduce pressure in front of the rocket?

Observations

Students should observe:
- The flat surface experienced the most force, almost being blown away.
- The pointed cone experienced the least resistance, allowing the air to pass by without pushing the model.
- Higher fan speeds caused a dis-proportionately larger push, demonstrating that speed is the biggest factor in air pressure.

Analysis and Conclusion

The experiment shows that air exerts force on moving objects, with drag increasing as speed rises. A larger surface area increases this resistance, while streamlined shapes effectively reduce drag and allow for smoother motion. Wind resistance is a force that opposes motion through the air, directly affecting a rocket's trajectory. Therefore, rocket design must minimize drag to improve both fuel efficiency and overall flight performance.

Did You Know?

Rockets can form a vapor “halo” cloud when passing Max-Q due to sudden pressure drops.

Where Else Do We See This Science?

- Airplanes are designed with streamlined shapes to reduce air resistance and improve speed and fuel efficiency
- Cars are shaped aerodynamically to reduce drag and move smoothly through air
- Parachutes use large surface area to increase air resistance and slow down descent
- Cyclists and athletes wear tight suits and helmets to reduce drag and move faster

Precautions & Safety

⚠ Keep hands away from fan blades.

⚠ Ensure fan is placed on stable surface.

⚠ Do not insert objects into fan.

⚠ Supervise students during activity.

Additional Links

(Basics of Openrocket software)
https://youtu.be/z16_uUnMarE?si=X_qAwf32XltZru7J

(Starship flight)
https://youtu.be/C3iHAgwIYtI?si=i64_2Ixyv-MdVP5k

Answer: Pre-Activity Engagement 1. A 2. C, Self-Assessment 1. B 2. C 3. A 4. B

01 Launch

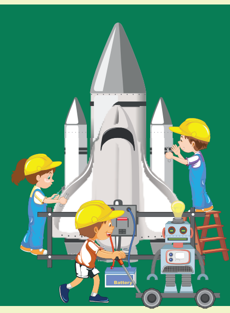
From Countdown to Orbit Insertion

1.4 Balloon Two-Stage Rocket

To design and demonstrate a simple two-stage rocket model using balloons and understand the concept of staging in rocket launches.

Objective

a. **To understand the concept of multi-stage rockets.**
b. **To observe thrust generation using air pressure.**
c. **To learn why staging improves rocket efficiency.**
d. **To compare single-stage and two-stage systems.**
e. **To develop basic model-design skills.**

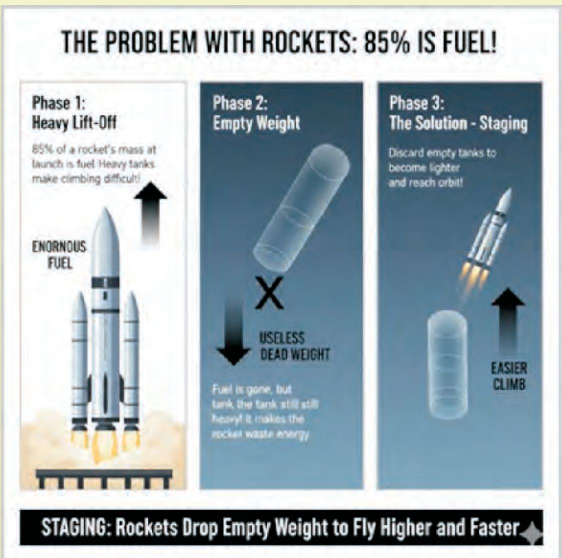


Scientific Foundation

The Big Question – Why Not Just One Giant Rocket?

Imagine you are going on a long hike up a mountain. At the beginning of the hike, you carry a backpack full of water bottles. The bag is heavy, and walking feels difficult. Halfway up the mountain, you have drunk most of the water. Now the bottles are empty. Ask yourself: Would you keep carrying all those empty bottles to the top?

Of course not. They are no longer useful. They only make your bag heavier and slow you down. You would throw them on a dustbin to reduce the burden. These empty bottles are called **dead weight** - weight that no longer helps you but still must be carried. Rockets face the same problem.



The Problem of Fuel and Weight in Rockets

To reach space, rockets need an enormous amount of fuel. In fact, about **85% of a rocket's mass at launch is fuel.** This fuel is stored in large, heavy tanks. Once the fuel inside a tank is burned, the empty tank becomes useless. It cannot produce thrust anymore, but it is still heavy. If the rocket keeps carrying these empty tanks, it wastes energy lifting something that has no purpose. This makes it extremely difficult, and sometimes impossible, to reach orbit.

The Solution – Multistaging

A stage is a section of the rocket that has its own fuel tank and engine. When one stage finishes its fuel, it is separated and dropped. Instantly, the rocket becomes lighter, and the next stage ignites to push it forward more efficiently. This process is called multistaging. Multistaging is similar to removing unnecessary weight during a journey, allowing the system to move faster and use energy more efficiently.

How Staging Works & Stability

Relay Race Analogy

Think of a relay race in sports. Runner 1 starts the race and runs hard. After finishing their part, they pass the baton and stop. Runner 2 continues the race with fresh energy. A multistage rocket works the same way.

Stage 1 – The Muscle Runner

This is the biggest and strongest stage. Its job is to lift the entire heavy rocket off the ground and push through thick air near Earth.

Stage 2 – The Speed Runner

This stage starts after Stage 1 drops away. Because it is lighter and higher up where air is thin, it can go much faster and help reach orbit.

The Launch Sequence

A multistage launch happens in a carefully planned order:

1. Stage 1 engines ignite →Rocket lifts off.
2. Stage 1 fuel finishes →Separation occurs.
3. Stage 1 falls away.
4. Stage 2 engine ignites→Rocket continues upward and forward.

Every step must happen at the correct time.

Stability – The Arrow Rule Again

Even multistage rockets must remain stable.At launch, fins are usually placed on Stage 1 to keep the whole rocket pointing straight.After Stage 1 separates, Stage 2 becomes a new rocket. It must also be balanced and stable.If a

Real-World Connection

Launch vehicles developed by ISRO such as PSLV and GSLV are multi-stage rockets. Similarly, NASA uses multi-stage systems like the Space Launch System (SLS), where boosters separate after fuel burnout.

Staging is essential for reaching orbit and deep space missions for space agencies.

Pre-Activity Engagement

Estimation Challenge

1. **What do you think makes a rocket move forward?**
   A. Gravity B. Air pushing backward C. Magnetism
2. **Which rocket will go farther?**
   A. One big rocket (single stage) B. Two smaller stages working one after another

Quick Demonstration (30–60 sec)

Inflate a balloon and release it

Ask:

"What direction does the air go?"- Backward

"Which direction does the balloon move?"

- Forward ,

Connect:"This is called action–reaction, the basic principle behind rockets"

Puzzle / Thought Experiment

If a rocket keeps all its empty fuel tanks attached, will it go faster or slower? Why?

Why do real rockets break into stages instead of staying as one single piece?

Lets start with the activity

Materials Required

1) Two long balloons (different colors, e.g., Red for Stage 1, Blue for Stage 2).
2) A long fishing line or smooth string strung across the room (the track).
3) Two drinking straws.
4) Tape (Masking tape or painter's tape works best).
5) Two binder clips (to hold air in).
6) The Trigger Mechanism: A piece of string (about 12 inches long).

Working Principle

The balloon rocket works on the principle of action and reaction.

Air is filled into the balloon. When released, air rushes out backward. The balloon moves forward due to reaction force.

In a two-stage model: First balloon releases air and moves forward. After it deflates, the second balloon releases air. This simulates stage separation and continued propulsion.

(Balloon Rocket Science Experiment)

https://www.youtube.com/watch?v=TfZsGy_q9zA

Procedure

1. Prepare the Track:
Stretch a long fishing line across the room and thread two straws onto it. This will act as the path for the rocket.

2. Set Up Stage 2 (Blue Balloon):
Inflate the blue balloon fully, twist its nozzle, and secure it with a binder clip (do not tie it). Tape this balloon firmly to the front straw (towards the finish side). This represents the second stage or payload.

3. Set Up Stage 1 (Red Balloon):
Inflate the red balloon, twist its nozzle, and secure it with a binder clip. Tape this balloon to the back straw, just behind the blue balloon. Ensure both balloon nozzles are pointing backward.

4. Create the Staging Trigger:
Take a 12-inch string and tie one end to the nozzle of the red balloon (Stage 1). Tie the other end to the binder clip of the blue balloon (Stage 2). This setup will allow Stage 1 to release Stage 2 automatically after it finishes.

5. Pre-Launch Setup:
Move both balloons to the starting end of the string. Check that the trigger string is not tangled and everything is aligned properly.

6. Launch the Rocket:
Start a countdown: "3… 2… 1…" Quickly remove the binder clip from the red balloon only to begin Stage 1.

7. Observe Stage 1 Motion:
The red balloon will release air and push both balloons forward together as a single system.

8. Observe Stage Separation:
As the red balloon loses air and shrinks, it pulls the string, which removes the clip from the blue balloon.

9. Observe Stage 2 Motion:
The blue balloon is now released and moves forward faster, leaving the deflated red balloon behind. This demonstrates how multi-stage rockets drop weight and continue moving efficiently.

Self-Assessment Trivia

1. **What principle makes a rocket move?**
   A. Gravity B. Action–Reaction C. Friction
2. **Why do rockets use multiple stages?**
   A. To look bigger B. To reduce weight and continue acceleration C. For decoration
3. **Air coming out backward pushes the rocket forward** A. True B. False
4. **Keeping empty fuel tanks attached helps the rocket go faster** A. True B. False

Thinking Questions

1. What happens when the first stage runs out of fuel?
2. Why does the second stage move faster after separation?

Observations

Students should observe:

- When the first-stage (red) balloon is released, both balloons move together along the string.
- The motion is steady but slow because one balloon is pushing the total weight of both.
- As the red balloon loses air, it shrinks and the speed slightly decreases.
- A small jerk is observed when the first stage becomes empty and separation occurs.
- After separation, the blue balloon accelerates quickly and moves faster.
- The deflated red balloon remains behind as dead weight.
- The second stage travels a longer distance than the combined system.
- If alignment is improper, wobbling or sideways motion is observed, showing the importance of stability.

Analysis and Conclusion

The experiment shows that releasing air backward produces forward motion, while a two-stage system allows for extended propulsion. Removing used stages significantly reduces the overall mass, which directly improves efficiency and increases the total travel distance.Multi-stage rockets are more efficient because they shed unnecessary weight during flight to allow for better acceleration. This process ensures the rocket can reach much higher altitudes by maximizing its power-to-weight ratio.

Did You Know?

Most rockets use multiple stages that separate just minutes after launch.

Where Else Do We See This Science?

- Space rockets use multiple stages to drop empty fuel tanks and become lighter during flight
- Missile systems use staging to improve speed and reach longer distances
- Relay races use multiple runners to maintain speed and efficiency over long distances
- Delivery systems and drones reduce load during travel to improve performance

Precautions & Safety

⚠ Ensure the string is tightly secured.
⚠ Do not overstretch balloons.
⚠ Avoid sharp objects near balloons.
⚠ Maintain safe distance during release.
⚠ Teacher supervision recommended.

Additional Links

(Two Stage ballon rocket)
https://youtu.be/Xcdld35SMHY?si=epeOqksrHdHx4WYK

(Ballon rocket)
https://youtube.com/shorts/dhGpyp33Xec?si=upiFkGTa6IUeGx7c

Answer: Pre-Activity Engagement 1. B 2. B, Self-Assessment 1. B 2. B 3. A 4. B

01 Launch

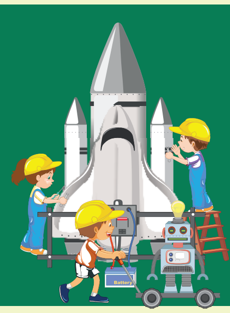
From Countdown to Orbit Insertion

1.5 Fairing Design Challenge

To design and test a protective rocket fairing that can safely protect an “egg payload” during a drop test and understand how shape and cushioning affect impact survival.

Objective

a. **To understand the purpose of a rocket fairing.**
b. **To learn how shape affects air resistance and stability.**
c. **To explore impact force and cushioning.**
d. **To test different nose cone designs.**
e. **To develop engineering problem-solving skills.**



Scientific Foundation

Rocket Fairings: The Ultimate Bodyguard for Space

Every rocket carries a precious "passenger" at its tip called the **Payload** (like a satellite). Because this payload is extremely delicate, expensive, and sensitive to heat and vibration, it needs a bodyguard. That bodyguard is the **Fairing**-the cone-shaped shell at the very top of the rocket.

The Battle with Air

As the rocket blasts off through Earth's dense atmosphere, it faces three major enemies. The Fairing is specially designed to fight them all:

- **The Air Punch :** At high speeds, air doesn't just move aside; it piles up and pushes back with massive force. The Fairing’s strong outer shell—made of high-tech materials like **aluminum alloys or carbon fiber**-spreads this pressure out so the satellite feels almost nothing.
- **The Heat Barrier :** Friction between air molecules and the fast-moving rocket creates intense heat, reaching hundreds of degrees Celsius! The Fairing acts as a **Heat Shield**, absorbing this energy so the satellite stays at a safe temperature.
- **The Shakes :** Launching is a bumpy ride. The Fairing and its internal mounts act like a **Helmet or Airbag**, using cushioning materials to absorb vibrations and shocks before they reach the payload.

Once the rocket reaches about **100 km high** (the **Karman Line**), it leaves the atmosphere and enters the **Vacuum** of space. In these **Vacuum Dynamics**, there is no more air pressure, no more friction, and no more heat. Suddenly, the protective Fairing is no longer needed.

The Final Sprint

In rocket science, the golden rule is **Multi-stage Optimization:** *Every extra kilogram of mass needs more fuel.* To reach the stars, the rocket must be as light as possible. Since the Fairing is now just "dead weight," the rocket uses separation mechanisms to split the shell into two halves and drop them (**Jettison**). By throwing away this extra weight, the **Upper Stage** becomes much lighter, allowing it to accelerate the satellite to a massive orbital velocity of **28,000 km/h**.

Real-World Connection

ISRO designs payload fairings for launch vehicles such as PSLV and GSLV.

NASA tests fairings in wind tunnels and vibration chambers before real missions.

After the rocket leaves Earth’s atmosphere, the fairing separates because air resistance is no longer present.

Pre-Activity Engagement

Estimation Challenge

1. **From what height do you think an egg can fall without breaking (without protection)?**
   A. 1 meter B. 3 meters C. 5 meters
2. **Which design will protect the egg better?**
   A. Flat covering B. Cone-shaped covering
   C. No covering

Quick Demonstration (30–60 sec)

Take a small object (like a chalk or eraser)

- Drop it directly → observe impact
- Then wrap it in cloth or tissue and drop again

Ask: "What changed?" Less damage due to cushioning

Connect: "This is how a rocket fairing protects the payload"

Puzzle / Thought Experiment

If you drop an egg without any protection, it breaks.But what if you wrap it in soft material and give it a pointed shape?Will it survive? Why? Which is more important for safety:
Shape (aerodynamics)Cushioning (soft materials)Or both? Explain your thinking.

Lets start with the activity

Materials Required

1) Raw eggs (one per group)
2) Chart paper or cardboard
3) Tape
4) Cotton/sponge/tissue paper
5) Rubber bands
6) Scissors
7) Measuring tape
8) Safe drop area

Working Principle

Students design a fairing structure around the egg and drop it from a fixed height. The survival of the egg indicates: Effectiveness of aerodynamic shape, Stability during fall Efficiency of the cushioning system

Procedure

1

Step 1: Introduce the Payload
The teacher explains that the egg represents a fragile satellite payload. Students are informed that their goal is to protect this payload using a self-designed fairing.

Step 2: Design the Fairing Structure
Students design and build fairings using paper, cardboard, or similar materials. Different nose shapes such as cone-shaped, rounded, or cylindrical designs are encouraged for comparison.

2

3

Step 3: Add Cushioning Material
Soft materials such as cotton, sponge, tissue paper, or foam are placed around the egg to absorb shock during impact.

Step 4: Secure the Payload
Students ensure that the egg is held firmly inside the fairing and does not move freely. The structure should be stable and properly sealed.

4

5

Step 5: Perform the Drop Test
Under teacher supervision, the fairing is dropped vertically from a fixed height onto a safe testing surface.

Step 6: Observe and Record Results
Students carefully open the fairing and check whether the egg is intact or cracked. Observations are recorded.

Step 7: Redesign and Improve
Based on results, students modify their fairing design and repeat the test to improve payload protection.

Self-Assessment Trivia

1. **What is the main purpose of a fairing?**
   A. Decoration B. Protect the payload C. Increase weight
2. **What helps reduce damage during impact?**
   A. Hard surface B. Cushioning material C. More weight
3. **A pointed shape helps reduce air resistance** A. True B. False
4. **A loose payload inside the structure is safe** A. True B. False

Thinking Questions

1. Why is it important to keep the payload stable inside the structure?
2. How did changing the shape or material improve your design?

Observations

Students should observe:
- Which shape falls more steadily.
- Which design protects the egg best.
- How cushioning affects impact.
- How stability influences landing orientation.

Analysis and Conclusion

The experiment shows that streamlined shapes effectively reduce drag, while balanced designs significantly improve flight stability. Using cushioning increases the stopping time during impact, which reduces the total force acting on the internal components.A rocket fairing must protect the payload both aerodynamically and structurally throughout the mission. Successful design requires a deep understanding of air resistance and impact physics to ensure the safety of the satellite.

Did You Know?

Rocket fairings are built to withstand extreme pressure and are discarded after leaving the atmosphere.

Where Else Do We See This Science?

- Helmets protect the human head by absorbing impact and reducing injury during accidents
- Airbags in cars use cushioning to reduce force during collisions and keep passengers safe
- Packaging materials like bubble wrap protect fragile items from damage during transport
- Mobile phone cases are designed to absorb shock and prevent damage when dropped

Precautions & Safety

⚠ Conduct drop test under supervision.
⚠ Maintain safe distance during drop.
⚠ Clean broken eggs immediately.
⚠ Handle scissors carefully. Ensure stable drop height.

Additional Links

(Fairing separation of Falcon9)
https://youtube.com/shorts/KeOUXgeG8v0?si=BobLJ83fKtddEcZ0

(Fairing separation of Starlink)
https://youtube.com/shorts/W7E26teqY0U?si=TPSTa5oLpdEutOtZ

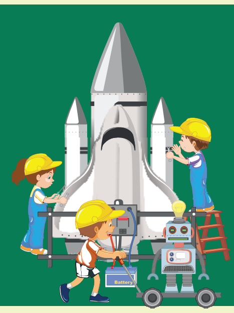
Answer: Pre-Activity Engagement 1. A 2. B, Self-Assessment 1. B 2. B 3. A 4. B

1.6 Ball on String Orbit Demo

To understand how objects stay in orbit by balancing speed and force, using a ball and string model.

Objective

a. **To understand how an object can move in a circular path.**
b. **To learn how force and speed help an object stay in orbit.**
c. **To observe how changing speed affects motion.**
d. **To relate the activity to how satellites move around Earth.**



Scientific Foundation

Choosing the Launch Site - Where Should We Launch From?

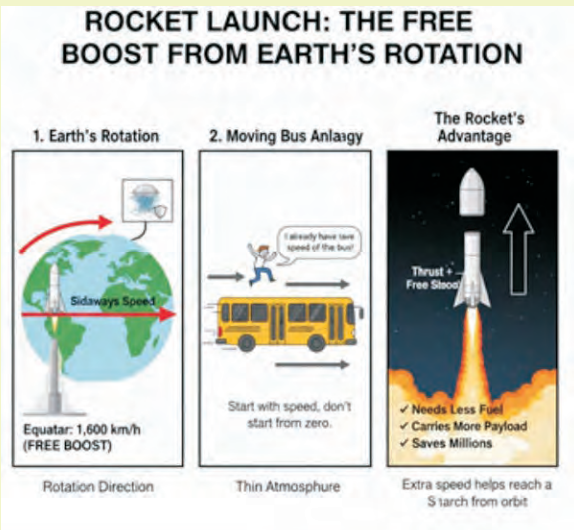
Many students notice that major space agencies launch rockets from coastal locations that are closer to the Equator. For example, India launches most of its rockets from Sriharikota, and the United States launches from Florida. This is not a coincidence. It is a result of Earth's motion and physics.

The Earth Is Like a Giant Merry-Go-Round

Earth is constantly rotating around its axis, just like a giant playground merry-go-round.

On a merry-go-round: The center moves slowly. The edges move much faster.

Earth behaves in the same way.The North Pole and South Pole are like the center of the merry-go-round. They move slowly. The Equator is like the outer edge. It moves the fastest.



At the Equator, Earth's surface moves at about **1,600 kilometers** per hour due to rotation.

This means that anything sitting on the Equator is already moving very fast, even though we do not feel it.

The "Free Boost" Advantage

Rocket scientists take advantage of Earth's rotation.

When a rocket is launched near the Equator and in the same direction as Earth's rotation, it already has a large amount of sideways speed before the engines even start working fully.

This is similar to jumping off a moving bus. When you jump, you already have the speed of the bus. You do not start from zero.This extra speed is called a free boost.

Because of this free boost: The rocket needs less fuel ,The rocket can carry more useful payload, Millions of dollars are saved.This is why launch sites are chosen near the Equator whenever possible.

Real-World Connection

ISRO launches many rockets eastward from Sriharikota to benefit from Earth's rotational speed. Similarly, NASA launches rockets from Florida in an eastward direction for the same reason to gain additional velocity from Earth's spin. Understanding Earth's rotation is important for space agencies when calculating satellite paths and launch trajectories.

Pre-Activity Engagement

Estimation Challenge

1. **Which part of Earth moves faster due to rotation?**
   A. Poles B. Equator C. Same everywhere
2. **From where is it easier to launch a rocket into space?**
   A. Near the Poles B. Near the Equator
   C. Anywhere

Quick Demonstration (30–60 sec)

Ask a student to:

- Stand still and throw a ball straight
- Then slowly spin and try to throw the ball again

Ask:"What changed?" The ball no longer goes straight

Connect: "This is similar to what happens when rockets launch from a rotating Earth"

Puzzle / Thought Experiment

If Earth is spinning, why don't we feel like we are moving?

If you throw a ball while standing still vs while spinning,will the path be the same or different? Why?

Lets start with the activity

Materials Required

1) Small ball (rubber ball or foam ball)
2) Strong string (1–2 meters long)
3) Open space (classroom or ground)
4) Measuring tape (optional)
5) Marker or chalk (optional, to mark circle)

Working Principle

When a ball is tied to a string and swung in a circle, the string pulls the ball inward. This inward force is called centripetal force. At the same time, the ball keeps moving forward due to its velocity. The balance between inward pull and forward motion creates a circular path, similar to how satellites orbit Earth.

Procedure

1 **Step 1: Setup**
Tie the ball securely to one end of the string. Hold the other end firmly in your hand.

2 **Step 2: Start Slow Rotation**
Swing the ball in a horizontal circle slowly. Observe the circular motion.

3 **Step 3: Increase Speed**
Gradually increase the speed of rotation. Notice that the string becomes tighter.

4 **Step 4: Observe Force**
Feel the pull in your hand. This pull represents the force needed to keep the ball in orbit.

Step 5: Reduce Speed
Slow down the rotation. Observe that the ball starts to fall inward and loses its circular path.

Step 6: Release (Optional-with safety)
Carefully release the string while swinging. Observe that the ball moves in a straight line.

Step 7: Change Radius
Use different string lengths and repeat the experiment. Observe how radius affects motion.

Self-Assessment Trivia

1. **Which part of Earth moves the fastest?**
   A. Poles B. Equator C. Both same
2. **Why is launching from the Equator beneficial?**
   A. More gravity B. Higher speed due to Earth's rotation C. Less air
3. **Objects at the Equator experience higher outward effect** A. True B. False
4. **Motion of Earth has no effect on rocket launch** A. True B. False

Thinking Questions

1. Why did the arrow at the Equator fly off more easily than the one at the Pole?
2. How does Earth's rotation help rockets save fuel?

Observations

Students should observe:
- At higher speed, the ball moves in a stable circular path.
- At lower speed, the ball falls inward.
- If released, the ball moves in a straight line.
- Longer string creates a larger circular path.

Analysis and Conclusion

The experiment shows that when we swing a ball on a string, the inward pull keeps the ball moving in a circular path. Similarly, in space, gravity pulls satellites toward Earth, but if they move at the right speed, they maintain a stable orbit instead of falling inward or moving away. An object stays in orbit when its forward motion and the inward pull of gravity are perfectly balanced. This balance is exactly how satellites remain around Earth, as their speed keeps them moving forward while gravity provides the necessary pull to maintain their path.

Did You Know?

Astronauts feel weightless because they are constantly falling around Earth in orbit.

Where Else Do We See This Science?

- Satellites stay in orbit around Earth by balancing their speed with gravitational force
- The Moon moves around Earth in a stable orbit due to gravity and forward motion
- Planets revolve around the Sun in circular or elliptical orbits due to gravitational pull
- A stone tied to a string moves in a circular path when swung due to inward force
- Roller coasters use circular motion and forces to safely move along curved tracks

Precautions & Safety

⚠ Ensure sufficient open space
⚠ Do not swing the ball near other students
⚠ Hold the string firmly
⚠ Use a lightweight ball
⚠ Do not rotate at very high speed
⚠ Teacher supervision required

Answer:-Pre-Activity Engagement 1. B 2. B , Self-Assessment 1. B 2. B 3. A 4. B

02 On-Orbit

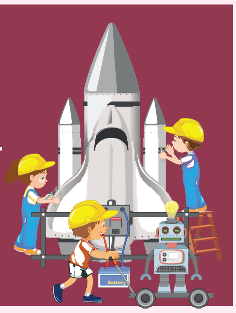
Operations in the Orbital Environment

2.1 Satellite Orbit Establishment and Tracking

To track the International Space Station (ISS) in real-time and understand how a satellite establishes and maintains a stable path around Earth.

Objective

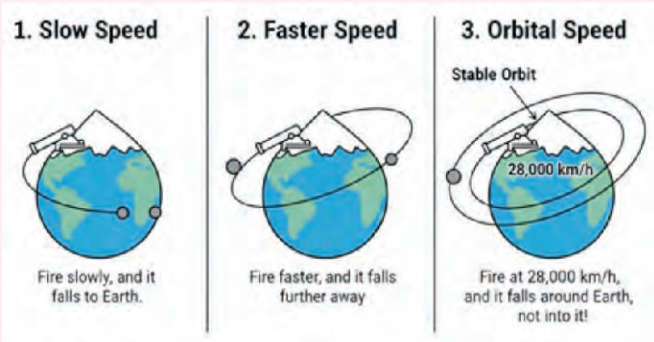
a. **Understand Orbital Velocity:** To learn why satellites stay in space instead of falling to the ground.
b. **Visualize Ground Tracks:** To observe how a satellite's path moves across a 3D globe.
c. **Master TLE Data:** To use real-time tracking apps and predict overhead passes.
d. **Differentiate Motion:** To understand the difference between the satellite's movement and Earth's rotation.



Scientific Foundation

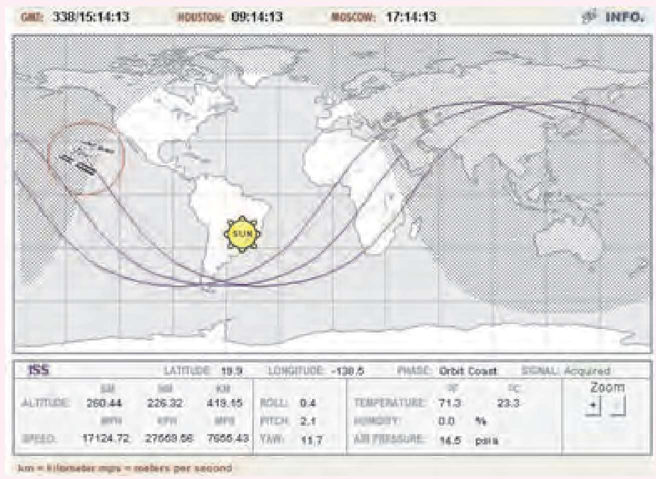
1. Newton's Cannon: The Secret of Falling How does a satellite stay "up"? It is actually **falling** toward Earth every second. However, it is also moving sideways very, very fast.

Imagine a cannon on a high mountain. If you fire a ball, it falls to Earth in a curve. If you fire it faster, the curve gets longer. If you fire it at **28,000 km/h**, the curve of the ball's fall matches the **curvature of the Earth**. The satellite falls *around* the Earth rather than *into* it. This is called a stable orbit.



2. Establishing the Initial Orbit When a rocket reaches space, it must perform an "Orbital Injection." This is the moment the engines tilt sideways to give the satellite enough speed.

- **Too Slow:** The satellite falls back and burns in the atmosphere.
- **Too Fast:** The satellite escapes Earth's gravity and flies into deep space.
- **Just Right:** The satellite establishes an "Initial Orbit."



3. The Ground Track Wave A satellite moves in a perfect circle around the center of the Earth. However, because the Earth is spinning like a top underneath the satellite, the path drawn on a flat map looks like a "wavy" line. This is called the **Ground Track.**

Real-World Connection

During **ISRO's Gaganyaan** missions, ground stations at Bangalore and Mauritius track the capsule every second. They use **TLE (Two-Line Element)** data a specific code that describes the satellite's exact position and speed to make sure the orbit hasn't changed due to atmospheric drag.

Pre-Activity Engagement

- **Estimation Challenge**

1. **How fast do you think a satellite like the ISS moves?**
   A. 100 km/h B. 1,000 km/h C. 27,000 km/h
2. **How much does Earth rotate in one hour?**
   A. 5° B. 15° C. 45°

- **Puzzle / Thought Experiment**

If a satellite is moving in space, is it following Earth's rotation or moving independently?

Why does the path of a satellite look different every time we observe it from Earth?

- **Quick Demonstration (30–60 sec)**

Take a globe (or imagine one)

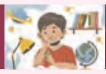
Hold a thread fixed around it (representing orbit)

Slowly rotate the globe

Ask: "What is moving?" -Earth is rotating -Orbit remains fixed

Connect: "This is why satellite paths appear to shift on Earth"

Lets start with the activity



Materials Required

1) Digital Tool: A tracking app (ISS Detector, Heavens-Above, or Stellarium).
2) 3D Model: A Physical Globe.
3) Marker: A dry-erase marker (whiteboard marker).
4) Data Source: Live Internet access for real-time coordinates.

Working Principle

The experiment operates on the principle of Relative Orbital Mechanics. It shows that while the satellite maintains a fixed plane in space, the Earth rotates 15 degrees every hour. This "relative" movement creates the changing path we see from the ground.

Software Setup:

Install any satellite tracking app such as:- ISS Detector (Android/iOS), Heavens-Above (website), Stellarium (mobile/desktop) These can be downloaded from the Google Play Store, Apple App Store, or accessed via their official websites. Ensure location access (GPS) is enabled for accurate tracking.

Procedure

1

Step 1: Locate the ISS
Open your tracking app and find the current "Live" position of the ISS.Note down the current **Latitude and Longitude (e.g., 20° N, 75° E).**

Step 2: Plotting on the Globe
Find that exact spot on your physical globe and mark it with a small dot using the marker. Wait for 10 minutes. The ISS travels at 7.6 km per second, so it will have moved significantly!

2

3

Step 3: Creating the Track
Check the new coordinates and mark a second dot.Repeat this 3-4 times. Connect the dots. You will see a diagonal line forming across the continents.

Step 4: The Full Orbit Visualization
Take a piece of string and wrap it around the globe in a full circle that passes through all your dots. This string represents the **Orbital Plane.** Rotate the globe slowly under the string to see how the Earth moves while the orbit stays fixed.

Step 5: Prediction Challenge
Use the "Passes" section of the app to find when the ISS will pass over your city.Note the Elevation (how high in the sky) and Direction (where to look).

Self-Assessment Trivia

1. **What causes the changing ground path of a satellite?**
   A. Satellite changing direction B. Earth's rotation C. Gravity changing
2. **What does an orbital plane represent?**
   A. Path of airplane B. Fixed path of satellite in space C. Earth's surface
3. **Satellites move exactly with Earth's rotation** A. True B. False
4. **Earth rotates approximately 15 degrees every hour** A. True B. False

Thinking Questions

1. Why does the ISS not pass over the same location every time?
2. How can we predict when a satellite will pass over our city?

Observations

Students should observe:
- The ISS takes only 90 minutes to go around the entire world once.
- The path on the globe is a straight diagonal line, but on a flat map, it looks like a curve.
- The ISS does not pass over the same spot twice in a row; it moves further west each time because the Earth is rotating.

Analysis and Conclusion

The tracking activity shows that a satellite remains in orbit because of the precise balance between gravity and its high sideways velocity. Gravity continuously pulls the satellite toward Earth, but its forward speed causes it to constantly "miss" the ground, creating a continuous curved path.Establishing a stable orbit depends not just on altitude, but on achieving the correct balance between velocity and gravitational pull. This experiment confirms that maintaining a specific orbital path is a result of these two forces working in perfect synchronization.

Did You Know?

Astronauts on the ISS see about 16 sunrises and sunsets every day.

Where Else Do We See This Science?

- GPS on your phone works because 24 satellites maintain precise orbits, constantly sending location signals to Earth
- Weather forecasting satellites follow fixed orbital paths to capture consistent images of clouds and storms
- Air traffic control tracks aircraft positions in real time, just like ground stations track satellites overhead
- Wildlife researchers fit animals with GPS collars whose signals are received by orbiting satellites to track migration

Precautions & Safety

⚠ **Device Safety:** Do not use permanent markers on the globe.

⚠ **Sky Watching:** If observing the ISS at night, always stay in a safe, open area with an adult.

⚠ **Signal:** Tracking apps require a GPS/Data signal to be accurate; calibrate your compass before predicting.

Answer:-. Pre-Activity Engagement - 1. C 2. B , Self-Assessment - 1. B 2. B 3. B 4. A

02 On-Orbit

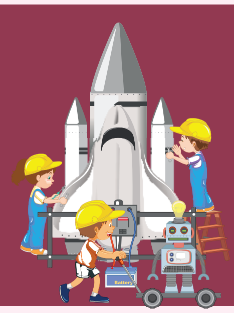
Operations in the Orbital Environment

2.2 Eclipse and Sun Region Demonstration

To understand how solar and lunar eclipses occur using a simple model of the Sun, Earth, and Moon.

Objective

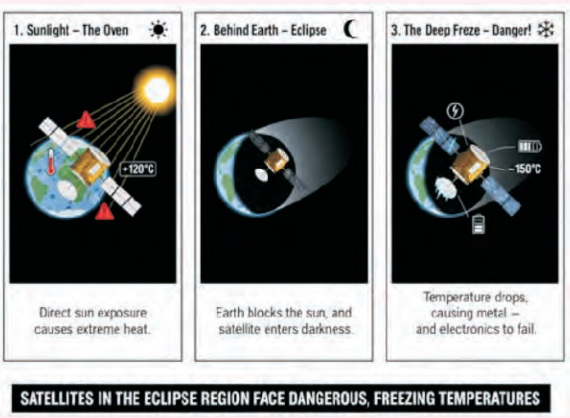
a. **To understand the alignment of the Sun, Earth, and Moon.**
b. **To differentiate between solar and lunar eclipses.**
c. **To observe shadow formation (umbra and penumbra).**
d. **To relate the model to real astronomical events.**
e. **To develop spatial visualization skills.**



Scientific Foundation

A satellite orbiting Earth constantly moves between two regions:
1. Sun Region – Facing the Sun **2. Eclipse Region** – Inside Earth's shadow

This change happens again and again as the satellite circles Earth. A satellite must survive both extremes. **Sunlit Region** When a satellite is directly facing the Sun: There is no atmosphere to block sunlight. Solar radiation hits the satellite strongly. The temperature can rise up to about **+120°C**. This is hotter than boiling water.



Such high temperatures can: Damage electronic circuits, Warp metal parts, Overheat batteries

Eclipse Region

When a satellite moves behind Earth: Earth blocks the Sun's light. The satellite enters darkness, called an eclipse. The temperature can drop to around **−150°C**. This is colder than the coldest places on Earth.Such low temperatures can: Make metals brittle, Reduce battery performance, Cause electronic failure.

Real-World Connection

ISRO studies eclipses to understand solar radiation and its effect on satellites.

Similarly, NASA observes eclipses to study the Sun's corona and improve space weather prediction.

Eclipse observations help scientists understand solar activity, which can affect communication satellites and power systems on Earth.

Pre-Activity Engagement

- **Estimation Challenge**

1. **What do you think is the temperature in space when sunlight directly hits a satellite?**
   A. 30°C B. 120°C C. 500°C
2. **What happens to temperature when a satellite goes into Earth's shadow?**
   A. Increases B. Stays same C. Drops very low

- **Puzzle / Thought Experiment**

If space has no air, how can something become extremely hot or extremely cold?

Why do astronauts and satellites face both extreme heat and extreme cold within a short time?

- **Quick Demonstration (30–60 sec)**

Use a torch and your hand:

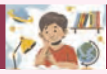
Shine the torch directly on your hand → feel warmth

Move your hand away or block the light → feel cooler

Ask: "What changed?" Direct light = more heat, No light=less heat

Connect: "This is similar to what happens to satellites in space"

Lets start with the activity



Materials Required

1) One large ball (Sun)
2) One medium ball (Earth)
3) One small ball (Moon)
4) Torch or lamp (light source)
5) Stand or holders
6) Dark room

Working Principle

This experiment demonstrates how a satellite experiences heating and cooling in space due to its position relative to the Sun and Earth. The torch represents the Sun, the large ball represents the Earth, and the small ball represents the satellite. When the satellite is in direct light, it absorbs energy and heats up, and when it moves into Earth's shadow, it loses heat and cools down.As the satellite moves continuously around the Earth, it repeatedly enters and exits sunlight, creating a cycle of high and low temperatures. This shows that temperature in space depends on sunlight exposure, and satellites must be designed to handle these rapid changes using thermal control systems.Observe formation of umbra and penumbra regions.

(Lunar and Solar Eclips)
https://www.youtube.com/watch?v=n7tnHPDH5d8

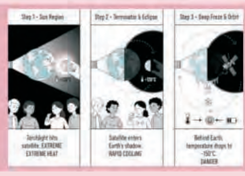
Procedure

Activity - The "Day & Night" Ball Demonstration
The classroom lights are switched off.
The torch is placed on one side of the table.
The large ball (Earth) is placed in the center.
The small ball (satellite) is moved around the Earth in a circular path.

1

Step 1 - Sun Region
The satellite is held between the torch and the Earth.
Students observe that the light falls directly on the satellite.
Explain that this represents **+120°C** conditions.

Step 2 - Terminator Line
The satellite is moved slowly to the side of Earth.
Half of the satellite is in light and half in shadow.
Explain that temperature is changing rapidly.



2

3

Step 3 - Eclipse Region
The satellite is moved behind Earth.
The torch light is blocked.
Explain that this represents - **150°C** conditions.

Step 4 - Continuous Orbit
The satellite is kept moving in a loop to show repeated heating and cooling cycles.

4

Self-Assessment Trivia

1. **Why does a satellite heat up in space?**
   A. Due to air friction B. Due to direct sunlight C. Due to gravity
2. **What happens when a satellite enters Earth's shadow?**
   A. It becomes hotter B. Temperature drops rapidly C. Nothing changes
3. **Space has uniform temperature everywhere** A. True B. False
4. **Satellites experience repeated heating and cooling cycles** A. True B. False

Thinking Questions

1. Why is temperature control important for satellites?
2. How do satellites survive extreme temperature changes?

Observations

Students should observe:
- Students observe that the satellite model becomes bright when facing the torch and completely dark when behind the Earth.
- They notice that the transition from light to dark happens quickly, showing how fast temperature changes occur in orbit.
- Students also observe that the satellite experiences both extreme conditions repeatedly, not just once.
- This helps them realize how difficult the space environment is for machines.

Analysis and Conclusion

This experiment shows that satellites experience rapid temperature changes as they move between sunlight and Earth's shadow. It helps students understand that space temperature is not constant. Therefore, satellites need proper thermal control systems to work safely in such extreme conditions.

Did You Know?

A solar eclipse reveals the Sun's outer atmosphere, called the corona.

Where Else Do We See This Science?

- Solar panels on buildings produce less electricity during cloudy days, just like satellites lose power in Earth's shadow
- Scientists use solar eclipses to study the Sun's corona, which is invisible during normal daylight

Precautions & Safety

⚠ Never look directly at the Sun.

⚠ Use proper eclipse glasses for real observation.

⚠ Handle the torch carefully.

⚠ Ensure stable placement of balls.

⚠ Avoid tripping hazards in a dark room

Answer:- Pre-Activity Engagement - 1. B 2. C , Self-Assessment 1. B 2. B 3. B 4. A

02 On-Orbit

Operations in the Orbital Environment

2.3 Thermal Control Hot and Cold Demo

To demonstrate how extreme temperature differences (thermal gradients) occur on a single object in a sunlit environment and to test how reflective insulation protects it.

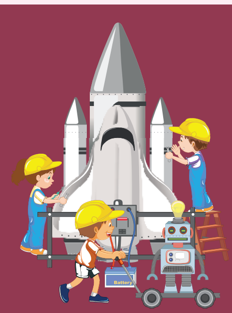
Objective

a. **Understand Heat Transfer: T**o observe how radiant energy (sunlight) heats surfaces without the presence of moving air.

b. **Observe Thermal Extremes:** To measure the simultaneous occurrence of "Boiling" and "Freezing" conditions on one object.

c. **Evaluate Insulation:** To test the effectiveness of reflective materials (MLI simulation) in controlling temperature.4+

d. **Engineering Application:** To relate the experiment to how satellites survive 16 "Oven-to-Freezer" cycles every day.



Scientific Foundation

Thermal **Challenges in Space: Surviving Extreme Temperatures**

In space, a satellite faces conditions far more extreme than anything we experience on Earth. It doesn't just face these conditions once it deals with them repeatedly, every single day.

1. The 90-Minute "Day and Night" Cycle

On Earth, we have 24 hours for a full cycle of day and night. But satellites move much faster!

The Example: The International Space Station (ISS) orbits Earth once every 90 minutes.

The Challenge: This means astronauts and satellites go from freezing darkness to scorching sunlight every 45 minutes. This constant "Hot-to-Cold" cycling is one of the biggest challenges in satellite engineering.

2. Why Space is Different: No Air (No Convection)

On Earth, air acts as a Thermal Equalizer. When the Sun heats a rock, the air around it gets warm and moves (wind), carrying that heat to the shaded side. This process is called Convection.

The Vacuum: In the vacuum of space, there is no air. The Problem: Without air, heat cannot be carried away by wind. If one side of a satellite gets hot, the heat stays stuck there unless we find another way to move it.

3. How Heat Moves in Space (Radiation)

In space, heat moves in only one way: Radiation (through light waves).

- **Heating Up (Inbound):** When sunlight hits a satellite directly, the energy is intense because there is no atmosphere to block it. Temperatures can soar to **+120°C** (hotter than boiling water!).
- **Cooling Down (Outbound):** On the dark side of Earth, the satellite faces the "Heat Sink" of deep space. It loses its internal heat instantly into the darkness, and temperatures can drop to **-150°C**.

4. The Thermal Gradient: Fire and Ice

Because heat doesn't move easily from the "Sun Side" to the "Shade Side," a **Thermal Gradient** (a big temperature difference) is created.Imagine holding a chocolate bar where one end is melting in a fire and the other end is freezing in ice that is what a satellite feels like!

5. The Solution: MLI (The Space Blanket)

To protect the delicate electronics inside, engineers wrap satellites in Multi-Layer Insulation (MLI). These are the shiny "Gold" or "Silver" blankets you see in NASA photos. **How do they work?**

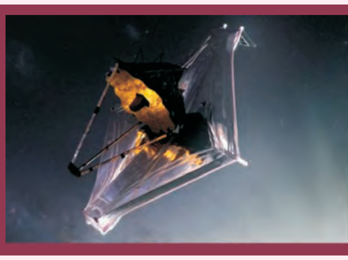
- **Like a Thermos Flask:** Just as a thermos keeps tea hot or water cold, MLI maintains a steady temperature inside the satellite.

- **Reflecting Sunlight:** The shiny outer surface acts like a mirror, reflecting sunlight away so the satellite doesn't overheat.
- **Trapping Heat:** The many thin layers inside act as a trap, keeping the satellite's own internal heat from escaping when it is in the cold darkness.

Note: MLI is most effective in the vacuum of space. In air, convection bypasses the insulating layers, which is why the classroom foil test only partially simulates real MLI performance.

Real-World Connection

The James Webb Space Telescope (JWST): The JWST has a giant 5-layer sunshield. One side faces the Sun and is hot enough to boil water (**85°C**). Just a few inches away, on the shaded side where the telescopes are, the temperature is a freezing **-233°C**. This experiment mimics that exact phenomenon.



Pre-Activity Engagement

Estimation Challenge

1. **What do you think is the temperature in space when sunlight directly hits a satellite?**
   A. 30°C B. 120°C C. 500°C
2. **What happens to temperature when a satellite goes into Earth's shadow?**
   A. Increases B. Stays same C. Drops very low

Puzzle / Thought Experiment

Why do people prefer wearing light-colored clothes in summer? If two objects are kept in sunlight one black and one white which one will heat up faster and why?

Quick Demonstration (30–60 sec)

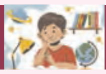
Show two objects (or imagine): Black paper, White paper

Ask students:"Which one will feel hotter in the sun?" Optional quick demo: Touch a black object and a light-colored object under sunlight

Black feels hotter

Connect:"This is because dark colors absorb more heat energy"

Lets start with the activity



Materials Required

1) **The Satellite Model:** A cardboard box (shoe box size).
2) **Surface Finishes:** One sheet of Black chart paper, one sheet of White chart paper.
3) **Thermal Barrier:** Aluminum foil (to simulate MLI).
4) **Measuring Tools:** Two digital thermometers (probe style) or an Infrared (IR) temperature gun or alcohol thermometer.
5) **Heat Source:** Direct noon sunlight or a high-wattage (500W) work lamp.

Working Principle

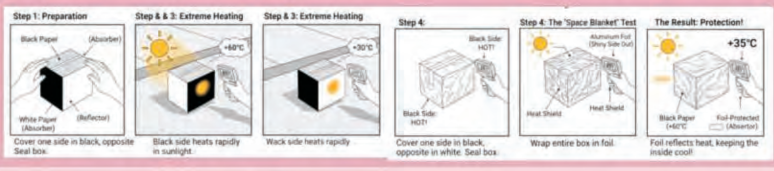
This experiment operates on the principle of **Surface Albedo and Radiative Balance**. It shows that dark colors absorb more radiant energy than light or reflective colors. By isolating the two sides of a box, we prevent thermal conduction from equalizing the temperature, creating a "Space-like" thermal split.

Procedure

1

Step 1: Preparation of the "Satellite"
Cover one side of your cardboard box with **Black paper** (The Absorber). Cover the exact opposite side with **White paper** (The Reflector).Seal the box completely with tape so no air flows inside.

Step 2: Positioning for the Sun
Take the box outside during peak sunlight (12:00 PM - 1:00 PM).Place it so the **Black side** is facing the Sun directly. Ensure the **White side** is in its own shadow.



2

3

Step 3: Taking the "Extreme" Readings
Wait for 15 minutes to let the surfaces heat up.Use your IR gun to measure the temperature of the Black side (Sun-facing).Quickly move to the back and measure the White side (Shaded). Record the data. (You will notice a massive difference).

Step 4: The "Space Blanket" Test
Now, wrap the entire box in Aluminum Foil (shiny side out). Place it back in the Sun for another 15 minutes. Measure the sun-facing side again. Compare this to the temperature of the unprotected Black paper.

4

Self-Assessment Trivia

1. **What is albedo?**
   A. Heat produced by an object B. Ability to reflect light C. Air pressure
2. **Which surface absorbs more heat?**
   A. White B. Black C. Shiny foil
3. **Light colors reflect more heat than dark colors** A. True B. False
4. **Aluminum foil increases heat absorption** A. True B. False

Thinking Questions

1. Why are satellites often covered with reflective materials?
2 How does using reflective surfaces help control temperature in space?

Observations

Students should observe:
- Unprotected Phase: The Black side will be significantly hotter than the ambient air (e.g., if air is 30°C, the black side might be 55°C). The shaded side will remain much cooler.
- Protected Phase: The Aluminum foil will reflect most of the light, keeping the surface temperature much closer to the ambient air temperature.
- The Gradient: Students will observe that the difference between the two sides can be as much as 20°C-30°C in just a few inches of distance.

Analysis and Conclusion

The experiment demonstrates that in an environment without air, an object's temperature is determined solely by how much light it absorbs or reflects. Active and Passive Thermal Control Systems are mandatory because a satellite cannot survive the extreme thermal split of space without assistance.Reflective coatings serve as the most effective way to protect delicate space electronics from intense solar radiation. By managing how energy is absorbed and reflected, these systems ensure the satellite maintains a stable temperature throughout its mission.

Did You Know?

Gaganyaan's heat shield can face 2000°C outside while staying cool on the inside.

Where Else Do We See This Science?

- Emergency "space blankets" used by hikers reflect body heat to prevent hypothermia in cold conditions
- White-painted rooftops in hot cities like Jaipur reflect sunlight to keep buildings naturally cooler
- Thermos flasks use reflective inner walls to keep drinks hot or cold for hours
- Wearing light-coloured clothes in summer reflects sunlight and keeps your body cooler

Precautions & Safety

⚠ Skin Protection: Wear a hat and use sunscreen if working under the noon sun for long.

⚠ Eye Safety: Do not stare at the sun or the bright reflection of the foil.

⚠ Lamp Warning: If using a lamp indoors, keep it at least

⚠ 1 foot away from the cardboard to prevent fire hazards.

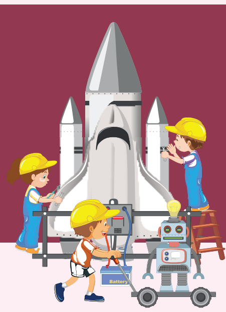
Answer:- Pre-Activity Engagement- 1. A 2. B, Self-Assessment 1. B 2. B 3. A 4. B

2.4 Spinning Stool Stabilization Demo

To demonstrate how a satellite controls its spinning speed and direction using the principle of Conservation of Angular Momentum.

Objective

a. To understand "Attitude Control" (the orientation of a satellite).
b. To learn how changing the distribution of mass affects rotation speed.
c. To observe the Conservation of Angular Momentum in action.
d. To relate this to how satellites use "Reaction Wheels" to stay stable.



Scientific Foundation

What is "Attitude" in Space?

In our daily life, attitude is how we behave. But in Space Science, **Attitude means Orientation** (which way the satellite is pointing).

- **The Problem:** Space has no floor or ceiling. A satellite can easily start tumbling or spinning in the wrong direction.
- **The Goal:** To take a clear picture of India, the camera must point **Down**. To get power, the solar panels must point at the **Sun**. If the "Attitude" is wrong, the mission fails!
- **Stabilization:** This is the science of keeping the satellite steady so it doesn't wobble like a spinning top.

Angular Momentum: The Power of the Spin

Every rotating object has **Angular Momentum** (Spinning Energy). Think of it as a "ghost force" that wants to keep the object spinning in the same direction forever. It is a balance between:

1. **Rotational Speed:** How fast it turns.
2. **Mass Distribution:** How far the weight is from the center.

Moment of Inertia:

Moment of Inertia is a measure of how difficult it is to start or stop a rotation. It depends on the mass of the object and how far that mass is from the rotation axis. More mass farther from the axis = greater moment of inertia = slower spin.

The Conservation Law (The "Ice Skater" Trick)

Physics says that **Angular Momentum cannot be destroyed;** it can only be shifted. This is the secret to controlling a satellite without using expensive fuel:

- **Tucking IN (Speed Up)**: Just like an ice skater pulls their arms in to spin like a blur, a satellite can move its parts inward to rotate faster.
- **Spreading OUT (Slow Down):** When the skater stretches their arms out, they slow down instantly. A satellite does the same by extending its parts outward.

Reaction Wheels: The Internal Steering

Real satellites have heavy spinning wheels inside them called Reaction Wheels. When a reaction wheel accelerates in one direction, the satellite experiences an equal and opposite torque, rotating it the other way. By controlling wheel speed across three wheels (one per axis), engineers can point the satellite in any direction.

Real-World Connection

Modern satellites developed by ISRO, such as Chandrayaan-3, use reaction wheels for orientation. Similarly, satellites developed by NASA, such as the James Webb Space Telescope, also use reaction wheels for precise control.These are heavy wheels inside the satellite. If the satellite needs to turn left, an electric motor spins the internal wheel to the right. Because of action–reaction, the entire satellite nudges in the opposite direction. No fuel is wasted a technique widely used by space agencies.

Pre-Activity Engagement

- **Estimation Challenge**

1. **When a spinning person pulls their arms inward, what will happen?**
   A. Speed decreases B. Speed increases C. No change
2. **Which condition makes rotation faster?**
   A. Mass far from center B. Mass close to center C. Both same

- **Puzzle / Thought Experiment**

Why do ice skaters spin faster when they pull their arms inward?

If you are spinning and suddenly stretch your arms outward, why does your speed decrease?

- **Quick Demonstration (30–60 sec)**

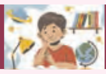
Ask a student to:

- Stand and rotate slowly with arms wide
- Then pull arms inward

Ask: “What changed?” Speed increases when arms come in

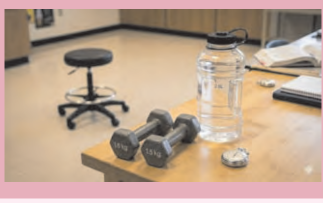
Connect: “This happens because the body changes how mass is distributed”

Lets start with the activity

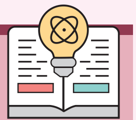


Materials Required

1) Rotating Stool/Chair: A chair that spins very smoothly (low friction).
2) Hand Weights: Two dumbbells (1-2 kg) or two heavy water bottles.
3) A Helper: To give the initial push.
4) Clear Space: To avoid hitting anything while spinning



Working Principle



This experiment works on Newton’s Laws of Rotation. By moving the weights closer to the axis of rotation, you decrease the "Moment of Inertia." To keep the Angular Momentum constant, the "Angular Velocity" (speed) must increase.

Procedure

1

The Setup: Sit straight on the rotating stool. Hold one weight in each hand.

2

Wide Start: Extend your arms fully to the sides, holding the weights far away from your body.

3 The Kick-start: Have a friend give you a gentle, steady push to start you spinning at a medium speed.

4 The "Speed Up" Move: While spinning, suddenly pull both weights in close to your chest.

5 ***Observation:*** You will feel yourself suddenly "zoom" and spin much faster!

6 The "Brake" Move: Extend your arms back out wide.

7 ***Observation:*** You will immediately slow down.

8 Repeat: Do this 2-3 times to feel the pull of the physics.

Self-Assessment Trivia

1. **What happens when mass moves closer to the center of rotation?**
   A. Speed decreases B. Speed increases C. No effect
2. **What is angular velocity?**
   A. Force of rotation B. Speed of rotation C. Direction of motion
3. **Pulling mass inward increases rotation speed** A. True B. False
4. **Angular momentum changes without any external force** A. True B. False

Thinking Questions

1. Why must speed increase when mass is pulled inward?
2. How is this concept useful in satellites or space systems?

Observations

Students should observe:

- When arms are extended, the spinning is slow and stable.
- When arms are pulled in, the speed increases dramatically without anyone pushing you again.
- The moment you move your arms, the speed changes instantly.

Analysis and Conclusion

We conclude that mass distribution controls rotation. Satellites use this to stay stable. If a satellite is spinning too fast, it can extend long booms (poles) to slow down. If it needs to turn quickly to face a new target, it pulls its mass inward or uses internal wheels to shift momentum.

Did You Know?

Ice skaters spin faster by pulling their arms in close to their body.

Where Else Do We See This Science?

- Ice skaters pull their arms inward to spin faster and stretch them out to slow down gracefully
- Divers and gymnasts tuck their bodies mid-air to spin quickly before straightening to land safely
- A spinning top stays upright due to the same gyroscopic stability used in satellite attitude control
- Helicopter tail rotors counteract the spinning force of the main rotor to keep the aircraft stable

Precautions & Safety

⚠ Don't over-spin: You might get dizzy and fall off.

⚠ Secure the weights: Make sure you have a firm grip so the weights don't fly off and hit someone.

⚠ Helper nearby: Have a helper stand at arm's reach infront of the student close by to stop the chair if you get too dizzy.

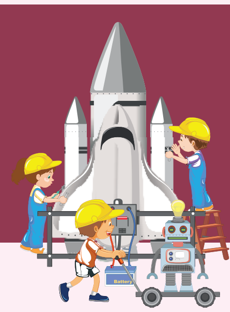
Answer:- Pre-Activity Engagement 1. B 2. B, Self-Assessment 1. B 2. B 3. A 4. B

2.5 Satellite Kit Integration Demo

To assemble a basic satellite model/kit and understand the main parts and working of a satellite.

Objective

a. **To identify the major components of a satellite.**
b. **To understand how satellites receive and transmit signals.**
c. **To learn how satellites generate power in space.**
d. **To relate the model to real communication and observation satellites.**
e. **To develop hands-on integration skills.**



Scientific Foundation

Every satellite is divided into two main parts. To understand them, think of a **Delivery Truck** carrying a **Giant Birthday Cake.** The Bus (the body) is the main structure of a satellite. It can be understood using a truck analogy: just like a truck has the engine, fuel, and steering system and its main job is to safely carry the cake to its destination, the bus of a satellite provides a "home" for all onboard systems. It is responsible for power supply, structural support, and protection of components. If the bus fails, the entire mission fails, because the "cake" (payload) will never reach its destination.

The Payload (The Mission)

The Payload is the actual equipment that performs the main job of the satellite. It can be understood using the cake analogy: this is the real reason for the journey. Examples of payloads include cameras to capture images of Earth, radios to transmit TV signals, or sensors to measure space radiation. Without a payload, there is no mission just an empty truck moving through space

The "Human Body" Connection

To make it easy for students, a satellite can be compared to a robotic human. The metal frame acts like a skeleton, giving the satellite its shape and strength. The On-Board Computer (OBC) works like the brain, controlling operations and running programs. Solar panels function like the stomach, converting sunlight into energy just as food provides energy to us. Antennas act like the mouth and ears, allowing the satellite to communicate with and receive signals from Earth.

Engineers break the satellite down into these "Subsystems." Here is how they work in your **Student Kit**:

1. **EPS (Electrical Power System)-The Heart**
   - **Job:** Collects energy from the Sun, stores it in batteries, and sends it to all parts.
   - **In your Kit**: This is your **Battery Pack** and **Power Wires**.

2. **OBC (On-Board Computer)-The Brain**
   - **Job:** It runs the software, collects sensor data, and sends out commands.
   - **In your Kit**: This is the Main **Microcontroller Board**.
3. **ADCS (Attitude & Direction)-The Balance**
   - **Job**: It makes sure the satellite is pointing correctly (Panels to the Sun, Cameras to Earth).
   - **In your Kit**: This is the **IMU / Gyroscope Sensor**.
4. **Communication (TT&C) - The Lifeline**

   This is the most important part! Without it, the satellite is "silent" and lost.
   - **Telemetry**: The satellite says, *"I am healthy!"*
   - **Tracking**: The satellite says, *"I am here!"*
   - **Command**: Earth says, *"Do this job now!"*
   - **In your Kit**: This is your **USB cable or Radio Module.**

Real-World Connection

ISRO operates satellites for communication (INSAT), navigation (NavIC), and Earth observation. Satellites are essential for GPS, television broadcasting, internet services, and disaster management.

Pre-Activity Engagement

Estimation Challenge

1. **How does a satellite send information to Earth?**
   A. Through wires B. Through signals (waves)
   C. It does not send anything
2. **What do you think is the "brain" of a satellite?**
   A. Battery B. Microcontroller C. Sensor

Puzzle / Thought Experiment

If a satellite has power but no communication system,
can we receive any data on Earth? Why?
If a sensor collects data but is not connected to the system, will the satellite still be useful?

Quick Demonstration (30–60 sec)

Show a simple example:

- Switch ON a device (like a torch or small electronic device)
- Then disconnect a wire

Ask: "What happened?" System stops working

Connect: "All systems must be connected properly for a satellite to work"

Lets start with the activity

Materials Required

1) Main microcontroller board
2) Battery pack
3) Temperature or light sensor
4) Jumper wires
5) USB cable
6) Laptop/computer

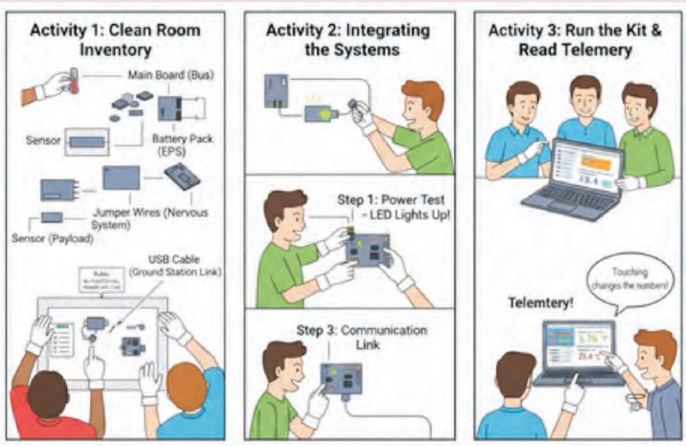
Working Principle

Power flows from the battery to the microcontroller. The microcontroller reads data from the sensor. The microcontroller sends this data to the laptop. This mimics how a real satellite senses its environment and communicates with Earth.

Procedure

Activity 1 – Clean Room Inventory
Students carefully observe all parts.

They identify: Main board (Bus), Battery pack (EPS), Sensor (Payload), Jumper wires (Nervous system), USB cable (Ground station link) Rules are followed to avoid damaging electronics.



Activity 2 – Integrating the Systems

Step 1- Power Test
Battery is connected to the board.
If LED lights up, power system is working.

Step 2 - Payload Integration
Sensor is connected to VCC, GND, and DATA pins.

Step 3 - Communication Link
USB cable is connected to laptop.

Activity 3 - Run the Kit & Read Telemetry

Software is opened.
Numbers appear on screen.
Students observe:

- Running time
- Battery voltage
- Temperature value

Touching the sensor changes the numbers.

Self-Assessment Trivia

1. **What is the role of a sensor in a satellite?**
   A. Provide power B. Collect data C. Control motion
2. **What does a microcontroller do?**
   A. Stores fuel B. Processes data C. Increases speed
3. **A satellite can work without power** A. True B. False
4. **Communication system sends data to Earth** A. True B. False

Thinking Questions

1. Why is it important for all systems to be connected properly?
2. What will happen if the battery stops working in a satellite?

Observations

Students should observe:

- Students observe that the board does not work without power, showing the importance of EPS.
- They observe that wrong wiring prevents data from appearing.
- They observe that touching the sensor causes an immediate change in values.
- Students realize that the satellite is sensing the environment and sending data.

Analysis and Conclusion

The activity demonstrates that satellites require multiple systems to function together, as power generation and communication systems are essential for continuous operation and connecting with Earth. Proper integration across these components ensures overall stability and efficiency during the mission.All satellite parts depend on each other, meaning that if one system fails, the entire mission is at risk. A satellite is truly a system of systems, where success relies on the seamless cooperation of every individual part.

Did You Know?

Satellites orbit Earth in different paths to power things like GPS and weather forecasts.

Where Else Do We See This Science?

- Smartphones combine a battery, processor, sensors, and antenna - exactly like a satellite's integrated subsystems
- Hospital patient monitors use power, sensors, and communication together to track and transmit health data
- Weather stations collect sensor data, process it, and transmit readings-just like a satellite sending telemetry
- Industrial robots use power, onboard computers, and sensors working together to perform tasks autonomously

Precautions & Safety

- ⚠ Handle kit components carefully.
- ⚠ Avoid forcing parts during assembly.
- ⚠ Follow the instruction manual properly.
- ⚠ Keep small parts away from younger children.
- ⚠ Teacher supervision recommended.

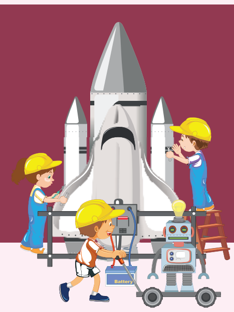
Answer:- Pre-Activity Engagement 1. B 2. B, Self-Assessment 1. B 2. B 3. B 4. A

2.6 Design Rover Model Using Waste Material

To design and build a simple space rover model using waste materials and understand how rovers explore planetary surfaces.

Objective

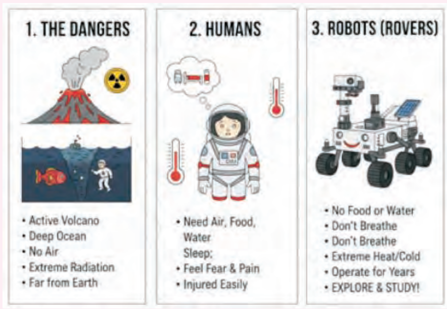
a. **To understand the purpose of space rovers.**
b. **To identify the basic parts of a rover.**
c. **To design a stable and movable rover model.**
d. **To promote reuse and sustainability using waste materials.**
e. **To connect rover design with real planetary missions.**



Scientific Foundation

Why Rovers? – Humans vs. Robots

Imagine you want to explore a very dangerous place, such as: The top of an active volcano The bottom of the deep ocean. Would it be safer to send a human or a robot?



Humans:

- Need air, food, water, and sleep, Can feel fear and pain, Can be injured easily

  Robots:
- Do not need food or water, Do not breathe, Can work in extreme heat or cold, Can operate for years

  Space is far more dangerous than any place on Earth.Other planets and moons:
- Have no air to breathe, Have extreme temperatures, Have strong radiation, Are very far from Earth

Because of these dangers, scientists usually send rovers instead of humans.

A rover is a robotic vehicle that can move around on the surface of another world, take pictures, study rocks, and perform experiments.Rovers are like **wheeled scientists.**

Goals of a Rover Mission Rovers are sent to other worlds to:

- Search for signs of water, Study rocks and soil, Learn how a planet formed, Test technologies for future human missions, Look for possible signs of life

Every rover mission has clear scientific goals.

The Parts of a Space Explorer

The Body

The chassis is the main body of the rover. It: Holds the computer and electronics, Protects parts from dust, cold, and heat, Is usually very strong and lightweight. Many rovers have heaters inside to keep electronics warm during cold nights.

The Wheels

Rovers use metal wheels, not rubber tires.

Reasons: Metal wheels are used because rubber cracks in extreme cold and degrades in vacuum and radiation. Metal wheels also have an open-grid design to reduce weight and provide traction on soft, dusty surfaces. Most rovers have **six wheels**. This helps them: Climb over rocks, Avoid getting stuck, Stay balanced on uneven ground.

The Head

The mast is a tall pole with cameras and sensors.

It: Acts like the rover's eyes, Takes panoramic images, Helps spot obstacles, Holds antennas for communication

The Robotic Arm

The robotic arm is like the rover's hand.

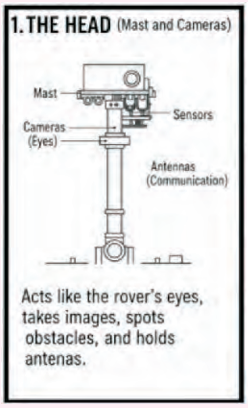
It can: Drill into rocks, Scoop soil, Place samples in the instruments

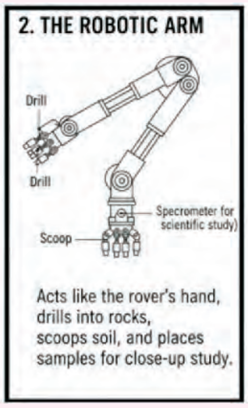
This allows close-up scientific study.

Power System

Rovers need electricity. Two main methods:

- **Solar Panels** – convert sunlight into electricity
- **RTG (Radioisotope Thermoelectric Generator)** – 'RTGs generate electricity from the heat produced by the natural radioactive decay of materials like Plutonium-238. They are not reactors and do not produce a nuclear reaction. RTGs are useful where sunlight is weak.





Real-World Connection

ISRO developed the Pragyan rover for lunar exploration. Similarly, NASA has sent several Mars rovers such as Perseverance and Curiosity to study the Martian surface.These rovers analyze soil, search for signs of water, and send valuable scientific data back to Earth an important function carried out by space agencies.

Pre-Activity Engagement

Estimation Challenge

1. **Which rover design will be more stable?**
   A. Narrow base with 2 wheels B. Wide base with 4–6 wheels C. Very tall structure
2. **What helps a rover move smoothly?**
   A. Fixed wheels B. Rotating wheels with axles C. No wheels

Puzzle / Thought Experiment

Why do space rovers (like those on Mars) have multiple wheels instead of just two?

If a rover is too tall and narrow, what might happen when it moves on uneven ground?

Quick Demonstration (30–60 sec)

Take two objects:

- A tall narrow object (like a bottle)
- A wide base object (like a box)

Gently push both Ask: "Which one falls more easily?", Tall narrow object tips easily

-Wide base object stays stable

Connect: "This is why rovers are designed with wide bases and multiple wheels"

Lets start with the activity

Materials Required

1) Cardboard boxes
2) Bottle caps (for wheels)
3) Ice cream sticks
4) Straws
5) Glue / Tape
6) Scissors
7) Skewers or sticks (for axles)
8) Small box (for body)
9) Chart paper for decoration

Working Principle

The rover model works on simple mechanical principles. The wheels are connected using axles, which rotate as the wheels move, allowing smooth motion. A balanced structure helps prevent the rover from tipping over, while a wide wheelbase improves stability on different surfaces. Students can also enhance the model by simulating solar panels using cardboard pieces and antennas using wires or sticks.

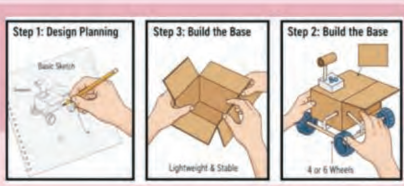
(Curiosity Rover)

https://www.youtube.com/watch?v=sSpfJeVpZSg

Procedure

Step 1: Design Planning
Draw a basic sketch of your rover.
Decide number of wheels (4 or 6).
Constraint: The rover body must fit within a 30 cm × 20 cm footprint and use only the materials listed.

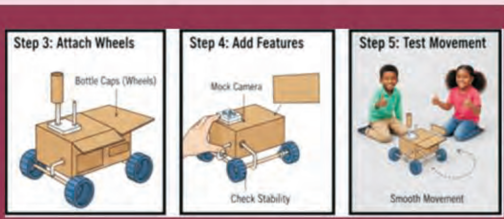
Step 2: Build the Base
Use cardboard to create the rover body.
Ensure it is lightweight and stable



Step 3: Attach Wheels
Insert sticks through straws to form axles. Attach bottle caps as wheels.

Step 4: Add Features
Attach a mock camera using a small box or a paper roll. Add a solar panel structure using flat cardboard pieces.

Step 5: Test Movement
Test on a flat classroom floor, and optionally test over a small obstacle (book, pencil) to simulate uneven terrain. Check stability and smooth movement.



Self-Assessment Trivia

1. **What is the role of an axle in a rover?**
   A. Store energy B. Help wheels rotate C. Increase weight
2. **Why do rovers have a wide wheelbase?**
   A. To look bigger B. To improve stability C. To reduce speed
3. **More wheels can improve rover stability** A. True B. False
4. **A narrow structure is more stable than a wide one** A. True B. False

Thinking Questions

1. Why is balance important for a rover moving on rough terrain?
2. How can you improve your rover design to make it more stable?

Observations

Students should observe:
- Smoothness of wheel rotation.
- Stability while moving.
- Effect of wheel size on movement.
- Balance of weight distribution

Analysis and Conclusion

The activity demonstrates that a stable base prevents tipping, while equal wheel alignment significantly improves smooth motion across different surfaces. A lightweight design is also essential as it improves overall mobility and ensures the rover can navigate efficiently. Rover design combines physics, mechanics, and creativity to solve the real challenges faced during planetary exploration. This process shows that successful engineering requires careful planning and constant testing to ensure the vehicle can survive harsh environments.

Did You Know?

Signals from Mars take 4 minutes when it's closest and 24 minutes at the farthest to reach Earth

Where Else Do We See This Science?

- Bomb disposal robots navigate dangerous areas remotely, keeping humans safely out of harm's way
- Agricultural robots move across fields on wide, stable wheel bases to spray crops and plant seeds
- Search and rescue robots crawl through earthquake rubble to locate survivors in unsafe areas
- Mining vehicles use wide wheelbases and multiple wheels to stay stable on rough, uneven terrain

Precautions & Safety

⚠ Handle scissors carefully.

⚠ Use glue safely.

⚠ Avoid sharp edges.

⚠ Ensure wheels are securely attached.

⚠ Teacher supervision recommended.

Answer:- Pre-Activity Engagement 1. B 2. B, Self-Assessment 1. B 2. B 3. A 4. B

03 Recovery / Re-entry

The Fiery Journey Home

3.1 Retrograde Burn Demonstration

To demonstrate how firing thrust in the opposite direction (retrograde burn) slows down a moving object and to understand why objects in space cannot simply "stop."

Objective

a. To understand the concept of motion in space.
b. To learn what a retrograde burn is.
c. To observe how thrust in the opposite direction reduces speed.
d. To relate the activity to satellite and spacecraft maneuvers.
e. To understand why stopping in space requires force

Scientific Foundation

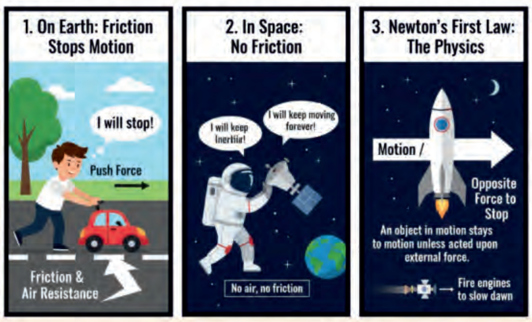
Motion Does Not Stop On Its Own

On Earth, when we push a toy car, it eventually stops. Why? Because friction from the ground and air slows it down. But in space, there is almost no air and very little friction. So if an object is moving in space, it will continue moving at the same speed unless a force acts on it.

This is explained by Newton's First Law of Motion:

An object in motion stays in motion unless acted upon by an external force.

This means spacecraft cannot simply "stop" by turning off engines. They must actively apply force in the opposite direction.

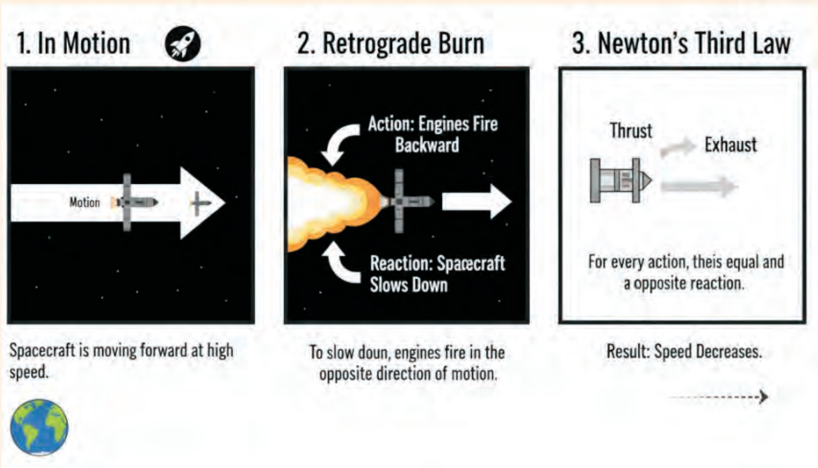


What Is a Retrograde Burn?

When a spacecraft wants to slow down, it performs a retrograde burn. "Retrograde" means opposite to the direction of motion. If the spacecraft is moving forward,the engine produces thrust in the opposite direction of motion, reducing the forward speed. When gas is expelled in one direction, the spacecraft moves in the opposite direction. This follows Newton's Third Law of Motion:

For every action, there is an equal and opposite reaction.

If the thrust is directed backward, the spacecraft's forward speed decreases.



Why Can't We Just Stop?

Imagine you are riding a bicycle in space (no friction). If you stop pedaling, will you stop moving? No. You will keep moving at the same speed. To slow down, you must apply force in the opposite direction. Spacecraft must carefully control their speed to enter orbit, land on planets, dock with space stations, re-enter Earth's atmosphere. Without retrograde burns, spacecraft would keep moving endlessly.

Real-World Connection

ISRO performs retrograde burns to place satellites into proper orbits and to deorbit spacecraft safely. Similarly, NASA uses retrograde burns for spacecraft docking and planetary landings. Retrograde burns are essential for safe re-entry and mission control in space agencies.

Pre-Activity Engagement

- **Estimation Challenge**

1. **When air is released backward, what will happen to the object?**
   A. It will move backward B. It will move forward C. It will not move
2. **How do you think a spacecraft slows down in space (where there is no friction)?**
   A. By brakes B. By reverse thrust C. It cannot slow down

- **Puzzle / Thought Experiment**

1. If a rocket is moving forward in space, how can it slow down without brakes?
2. What will happen if you push air forward instead of backward while moving?

- **Quick Demonstration (30–60 sec)**

Inflate a balloon and release it Ask:“In which direction does the balloon move?”, Opposite to the air flow Now explain:“If we push air in the opposite direction, we can slow down motion” Connect: “This is how spacecraft perform a retrograde burn to slow down”

Lets start with the activity

Materials Required

1) Balloon
2) Straw
3) String (3–4 meters)
4) Tape
5) Lightweight toy car or cardboard base
6) Two chairs or stands
7) Bottle caps (for wheels)

Working Principle

The balloon car works on Newton’s Third Law. When air rushes out of the balloon in one direction, the car moves in the opposite direction.

- To simulate a retrograde burn:
- Release air backward to move forward.
- Release air forward (reverse direction) to slow the car.

Procedure

1

Step 1: Setup Track
Tie a string tightly between two chairs.

Step 2: Attach Balloon
Tape a straw to the balloon and insert the string through the straw.

2

3

Step 3: Inflate Balloon
Inflate the balloon and hold it closed.

Step 4: Release Balloon
Let air escape and observe motion

4

5

Step 5: Retrograde Demonstration
Once moving, apply reverse thrust (manually demonstrate with the second balloon pushing in the opposite direction) to show the slowing effect.

1. **Which law explains the motion of a balloon rocket?**
   A. Newton's First Law B. Newton's Second Law C. Newton's Third Law
2. **What is a retrograde burn?**
   A. Increasing speed B. Slowing down using reverse thrust C. Changing direction randomly
3. **Air pushing backward makes the object move forward** A. True B. False
4. **Spacecraft need air to slow down in space** A. True B. False

Thinking Questions

1. Why can't spacecraft use brakes like cars?
2. How does changing the direction of thrust affect motion?

Observations

Students should observe the following:

- The balloon moves opposite to the escaping air.
- Faster air release causes greater motion.
- Opposite thrust reduces forward speed.
- Motion continues without friction.

Analysis and Conclusion

The experiment demonstrates that motion continues indefinitely without an external force, meaning objects in space cannot stop unless a specific force is applied. Therefore, applying thrust in the opposite direction is the only way to effectively reduce speed and change the vehicle's trajectory. In a retrograde burn, the rocket fires its engine in the forward direction so that the thrust pushes backward against its motion. This creates a strategic force opposite to its velocity, which successfully reduces its speed to allow for maneuvers like orbital decay or landing.

Did You Know?

Even tiny speed changes can significantly alter a spacecraft's orbit.

Where Else Do We See This Science?

- Aircraft use reverse thrust after landing to slow down rapidly on the runway
- Rowers paddle backward to slow or reverse a boat, applying force opposite to the motion
- Spacecraft docking with the ISS uses small retrograde burns to match speed precisely
- Cyclists apply brakes to create an opposing force in space, engines replace brakes entirely

Precautions & Safety

- ⚠ Ensure the string is tightly secured.
- ⚠ Do not overstretch the balloon.
- ⚠ Maintain a safe distance during release.
- ⚠ Avoid tripping over the string. Teacher supervision recommended

Answers:- Pre-activity 1.B 2.B , Self assessment Trivia -1. C 2.B 3.A 4.B

03 Recovery / Re-entry

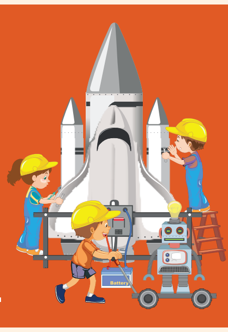
The Fiery Journey Home

3.2 Water Pebble Experiment

To understand why spacecraft experience extreme heat during atmospheric re-entry and to demonstrate heat generation using a simple water–pebble experiment.

Objective

a. **To understand atmospheric friction and heat generation.**
b. **To learn why spacecraft need heat shields.**
c. **To observe the temperature rise due to motion and friction.**
d. **To relate the experiment to a real spacecraft re-entry.**
e. **To develop observation and analytical skills.**
f. **To observe how blunt shapes push fluid away more strongly than sharp shapes.**



Scientific Foundation

When a spacecraft comes back to Earth, it isn't just "falling"it is slamming into an invisible wall of air at a massive speed of **27,000 km/h**. That is **25 times** faster than a jet plane!

1. The Invisible Wall of Air

Space looks empty, but it is actually filled with trillions of tiny air molecules. When a spacecraft hits these molecules at super-high speeds:The air doesn't feel soft anymore; it feels like a **solid wall.** The spacecraft "rubs" against these molecules, creating **Friction**. The air gets trapped and **Compressed** (squeezed) in front of the spacecraft.

2. Why does it get so Hot? (The Bicycle Pump Secret)

Have you ever noticed that a bicycle pump gets hot when you use it quickly? That's because **squeezing air creates heat.** During re-entry, the air is squeezed so hard and so fast that the temperature jumps to **1,600°C!.** This is hot enough to melt a car, a bus, or even a heavy steel beam.

How Do We Survive the Heat?

Engineers have to use "Space Magic" (Science!) to keep the astronauts safe inside.

Sharp vs. Blunt: The Shape Secret

- **The Sharp Nose (Bad for coming back):** A pointy nose is like a needle. It lets the heat touch the spacecraft directly at one tiny, super-hot point. This would melt the ship instantly.
- **The Blunt Body (The Hero):** A rounded, flat shape (like the bottom of a Capsule) is much safer. It creates a Shock Wave (a cushion of air) in front of the ship. This shock wave pushes the 1,600°C air away from the surface. It's like having an invisible umbrella that keeps the "fire rain" away from the ship!

Ablative Shields: The "Sacrifice" Shield

Most spacecraft use ablative heat shields, which are designed to "sacrifice" themselves to protect the mission. As the spacecraft re-enters the atmosphere, the outer layer of the shield gradually burns, turns into char, and flakes away. This process carries heat away from the surface, preventing it from reaching the inside. It works like sweating in the human body when sweat evaporates, it removes heat and cools the body. Similarly, the heat shield "sheds" its material to keep the spacecraft and astronauts safe.

Real-World Connection

ISRO designed heat shields for missions such as re-entry capsules and crew module tests. Similarly, NASA uses advanced thermal protection systems on spacecraft returning from orbit or deep space missions. Without heat shields, spacecraft would burn up during re-entry, making them essential for space agencies.

Pre-Activity Engagement

Estimation Challenge

1. How hot do you think a spacecraft gets during re-entry?

A. 100°C B. 500°C C. 1500°C+

2. Which shape do you think is safer for re-entry?

A. Sharp (pointy) B. Flat (blunt) C. No difference

Puzzle / Thought Experiment

Why don't spacecraft melt completely when they enter Earth's atmosphere at very high speed? If a spacecraft were shaped like a sharp pencil, would it survive re-entry? Why or why not?

Quick Demonstration (30–60 sec)

Drop a small object in water:

- Pointed object → small ripple
- Flat object → large splash

Ask: "What changed?" Flat shape creates stronger disturbance Connect: "This is similar to how a shock wave forms in front of a spacecraft"

Lets start with the activity

Materials Required

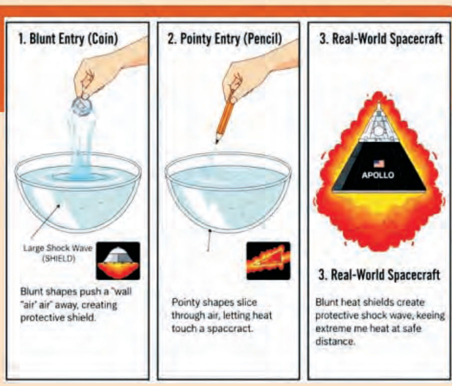
1) Large, clear bowl of water
2) Pencil (pointy object)
3) Flat coin or bottle cap

Procedure

Step 1 : Pointy Entry
Push the pencil tip quickly into water.

Observation:
Water moves aside gently. Very small ripple.

Step 2 : Blunt Entry
Slap the flat coin onto water surface.



Object	Observation (What happened?)	Scientific Meaning
Sharp Pencil	It slices through the water easily with almost no ripples.	A pointy rocket "slices" the air, letting 1,500°C heat touch and melt the surface directly.
Flat Coin	It creates a large splash and a big ripple that spreads out.	This big ripple is like a Shock Wave. It pushes the extreme heat away from the spacecraft.

Self-Assessment Trivia

1. **What is a shock wave?**
   A. Sound wave B. Strong disturbance in air due to high speed C. Heat energy
2. **Why are spacecraft heat shields blunt?**
   A. To increase speed B. To keep heat away from the surface C. To reduce weight
3. **Pointed shapes are safer for re-entry** A. True B.False
4. **Shock waves help protect spacecraft from extreme heat** A. True B.False

Thinking Questions

1. How does a blunt shape keep heat away from the spacecraft?
2. Why are special materials needed for heat shields?

Observations

Students should observe:

- Students observe that sharp objects cause small disturbances in water, while blunt objects create strong waves.
- They observe that metal heats quickly, cardboard burns, and ceramic resists heat.
- They realize that shape and material both control how heat behaves.

Analysis and Conclusion

The experiment demonstrates that motion and friction produce heat, with faster motion leading to a significant increase in temperature. Even a small amount of friction can cause a measurable thermal change, showing how kinetic energy is converted into heat during high-speed travel. During atmospheric re-entry, extremely high speeds cause intense heating due to air compression and friction against the atmosphere. Heat shields are therefore essential to protect the spacecraft and its internal systems from these extreme temperatures.

Did You Know?

Re-entry heat can exceed 1600°C hot enough to burn up meteors.

Where Else Do We See This Science?

- Meteors burn bright in the night sky due to the same atmospheric friction and compression as re-entry
- High-speed bullet trains use pointed nose cones to slice through air and reduce compression force
- Racing helmets are rounded and smooth to push air aside and reduce pressure on the rider's heat

Precautions & Safety

- ⚠ Safe Handling of Sharp Object
- ⚠ Use Stable Surface

Answers:- Pre-activity 1.C 2.B , Self assessment - 1.B 2.B 3.B 4.A

03 Recovery / Re-entry

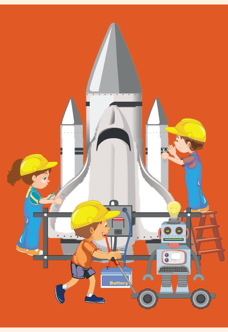
The Fiery Journey Home

3.3 Heat Shield Materials

To compare different materials and identify which material provides better thermal protection using a simple cotton heating experiment.

Objective

a. **To understand heat transfer mechanisms.**
b. **To compare insulating properties of different materials.**
c. **To learn how heat shields protect spacecraft.**
d. **To observe how materials respond to heat exposure.**
e. **To develop experimental comparison skills.**



Scientific Foundation

When a spacecraft returns to Earth at **27,000 km/h,** it encounters a wall of air that creates a glowing shroud of **Plasma**. At temperatures reaching **1,600°C,** ordinary metals like aluminum or steel would melt instantly. To protect the astronauts and the vehicle, aerospace engineers use two primary scientific strategies.

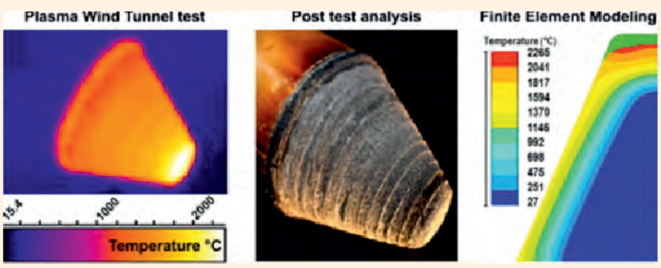
1. Thermal Insulation: The "Barrier" Method

This strategy is used for vehicles that need to be reused multiple times, such as the **Space Shuttle** or the **Dream Chaser.**

- **The Material (Silica Ceramic Tiles):** These specialized tiles are made of high-purity silica glass fibers. Remarkably, they are 90% air, making them extremely lightweight.
- **The "Oven Mitt" Logic:** Just as an oven mitt prevents heat from a hot tray from reaching your hand, these tiles act as a powerful barrier.
- **Low Thermal Conductivity:** These tiles are so efficient at blocking heat that an engineer can heat a tile in a furnace until it is glowing red-hot, yet still safely pick it up by its edges with bare fingers. The heat stays trapped on the surface and does not travel through the material.

2. Ablative Shielding: The "Sacrificial" Method

This strategy is used for deep-space capsules, such as NASA's **Orion** or ISRO's **Gaganyaan**.



- **The Material (Carbon-Phenolic Composites):** This is a heavy-duty mixture of carbon fibers and special resins designed to withstand extreme conditions.
- **The "Sweating" Logic:** When the human body overheats, it produces sweat. As sweat evaporates, it carries heat away from the skin. An ablative shield works in a similar way.
- **Controlled Erosion:** 1. As the plasma hits the shield, the outer layer chars and melts. 2. This chemical process absorbs the heat and carries it away as the charred pieces flake off into space. 3. By "sacrificing" the outer layer, the shield ensures that the fresh material underneath remains cool.

Real-World Connection

ISRO uses specialized thermal materials for spacecraft re-entry modules. Similarly, NASA developed heat-resistant tiles and ablative heat shields for returning spacecraft. Material selection is critical for astronaut safety and mission success in space agencies.

Pre-Activity Engagement

Estimation Challenge

1. Which material do you think allows heat to pass through the fastest?

A. Aluminum (metal) B. Cardboard C. Ceramic

2.Which material do you think will protect an object from heat the best?

A. Metal B. Paper C. Ceramic

Puzzle / Thought Experiment

If you touch a metal spoon and a wooden spoon kept near heat, which one feels hotter first? Why? Why do spacecraft not use only metal for protection from extreme heat?

Quick Demonstration (30–60 sec)

Take two objects:

- Metal object
- Wooden or plastic object

Expose both briefly to sunlight or heat

Ask: “Which one feels hotter?” Metal heats faster

Connect: “Different materials transfer heat differently”

Lets start with the activity

Materials Required

1) Candle or spirit lamp
2) Cotton ball (astronaut)
3) Aluminum foil
4) Cardboard
5) Ceramic tile or thick clay plate
6) Tongs
7) Stopwatch

Working Principle

The experiment compares heat conduction through different materials.

1. Place cotton behind a material sample.
2. Expose the material side to a heat source for equal time.
3. Observe changes in cotton (warm, slightly burnt, unchanged).
4. Compare which material best protects the cotton. Materials that transfer less heat are better insulators.

(Types of Heat Transfer)
https://www.youtube.com/watch?v=Me60Ti0E_rY

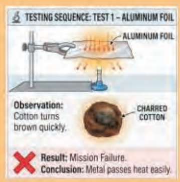
Procedure

1

Setup:- Hold the shield material about 2 cm above the flame. Place cotton ball on top of the shield.

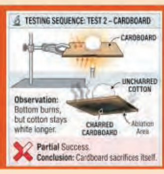
2

Testing Sequence
Test 1 – Aluminum Foil
Observation: Cotton turns brown quickly.
Conclusion:Metal passes heat easily.
Result: Mission Failure.

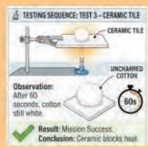


3

Test 2 – Cardboard
Observation: Bottom burns, but cotton stays white longer.
Conclusion:Cardboard sacrifices itself.
Result: Partial Success.



Test 3 – Ceramic Tile
Observation:After 60 seconds, cotton still white.
Conclusion: Ceramic blocks heat.
Result: Mission Success.



4

Self-Assessment Trivia

1.What is heat conduction?

A. Movement of air B. Transfer of heat through a material C. Light energy

2. Which material is the best insulator among the following?

A. Aluminum B. Cardboard C. Ceramic

3. Metals are good heat conductors A. True B. False

4. Insulators allow heat to pass quickly A. True B. False

Thinking Questions

1. Why is ceramic better than metal for heat protection?
2. How do spacecraft use insulating materials to survive extreme

Observations

Students should observe:

- Students observe that metal becomes hot very fast.
- They observe that cardboard burns but delays heat.
- They observe that ceramic resists heat transfer strongly.
- They see how different materials behave differently under the same flame.

Analysis and Conclusion

The experiment demonstrates that metal transfers heat quickly as a good conductor, while materials like cardboard act as effective insulators to slow down heat transfer. Although aluminium foil reflects some heat, it can also conduct it, meaning that specific insulating materials are necessary to provide superior thermal protection. Spacecraft require materials with high heat resistance and low heat transfer properties to survive the intense conditions of atmospheric re-entry. By selecting and combining these materials correctly, engineers can ensure that the internal systems remain safe even when the outer shell faces extreme temperatures.

Did You Know?

Some spacecraft use heat shields that burn away to protect them during re-entry.

Where Else Do We See This Science?

- Oven mitts use ceramic fibre to block heat, keeping hands safe from hot surfaces
- Firefighter jackets use layered insulating materials to protect against intense flames
- Building insulation like fiberglass traps heat inside homes during winter
- Ceramic mugs stay cool on the outside even when filled with boiling tea

Precautions & Safety

- ⚠ Perform only under teacher supervision.
- ⚠ Handle candle or heat source carefully.
- ⚠ Use tongs for holding materials.
- ⚠ Keep water nearby for safety.
- ⚠ Do not touch hot materials immediately.

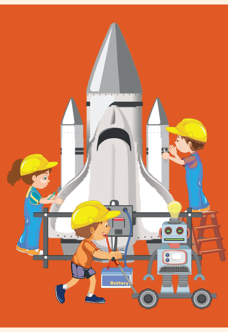
Answers:- Pre- activity 1. A 2. C, Self assessment 1.B 2.C 3.A 4.B

3.4 Parachute Design Challenge

To design and test different parachutes for an egg payload and understand how size, shape, and material affect descent speed and safe landing.

Objective

a. **To understand how parachutes reduce falling speed.**
b. **To explore the concept of air resistance (drag).**
c. **To test how surface area affects descent time.**
d. **To compare different parachute shapes and materials.**
e. **To develop design thinking and testing skills.**



Scientific Foundation

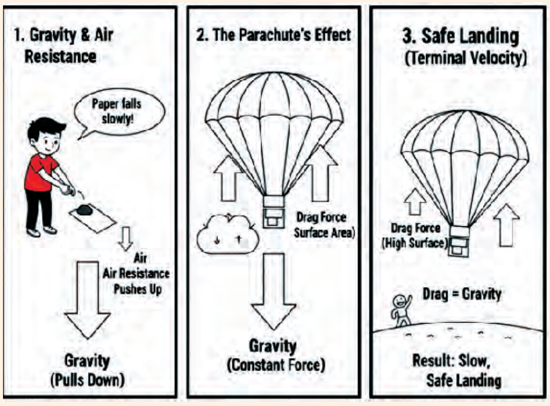
Why Don't Things Fall Slowly?

If you drop a stone and a piece of paper, what happens? The stone falls quickly. The paper falls slowly. Why? Because air pushes upward against falling objects. This upward force is called air resistance or drag. The greater the surface area exposed to air, the greater the drag force.

How a Parachute Works ?

When an object falls, gravity pulls it downward.

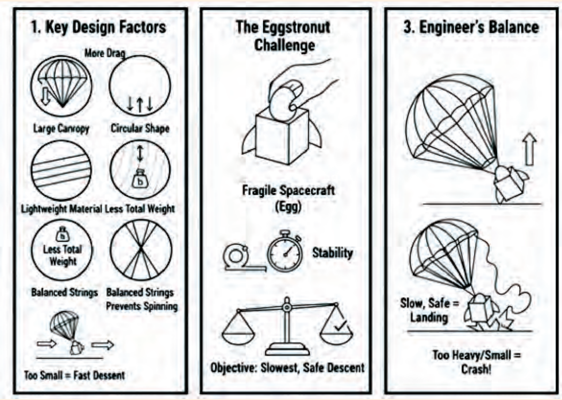
A parachute works by: Increasing surface area. Trapping air inside the canopy. Creating large upward drag force.



As air fills the parachute, it pushes upward against gravity. When the upward drag force becomes nearly equal to the downward gravitational force, the object reaches a steady slow speed called terminal velocity. This makes landing safer. Size, Shape, and Material Matter

Not all parachutes work the same. A larger canopy creates more drag.A circular shape distributes air evenly. A lightweight material reduces total weight. Balanced strings prevent spinning. If the parachute is too small, descent will be fast. If it is too heavy, it may not open properly.

Engineers must carefully balance: Surface area, Weight, Airflow stability. In this experiment, the egg represents a fragile spacecraft capsule. The goal is to achieve the slowest safe descent.



Real-World Connection

ISRO uses parachutes for safe recovery of crew modules and space capsules. NASA uses large parachutes for capsule landings and planetary missions.Parachutes are critical for safe re-entry and landing.

Pre-Activity Engagement

Estimation Challenge

1.Which parachute will fall slower?

A. Small canopy B. Large canopy C. No parachute

2. What increases air resistance (drag)?

A. Smaller surface area B. Larger surface area C. Weight only

Puzzle / Thought Experiment

Why do skydivers open parachutes before landing?

If two objects of the same weight are dropped one with a parachute and one without which will land first and why?

Quick Demonstration (30–60 sec)

Take two objects:

- A flat sheet of paper
- The same paper crumpled into a ball

Drop both at the same time Ask: “Which one falls slower?” Flat paper falls slower due to more air resistance Connect: “This is the same reason parachutes work”

Lets start with the activity

Materials Required

1) Raw eggs (one per group)/water balloon
2) Plastic bags / cloth / paper
3) Thread (equal lengths)
4) Tape
5) Scissors
6) Stopwatch
7) Safe drop area

Working Principle

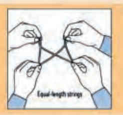
The parachute increases surface area, which increases air resistance. Greater drag force reduces descent speed. Slowest and safest landing indicates best aerodynamic design.

Procedure

1

Step 1: Design
Choose canopy size, shape, and material.

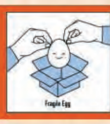
Step 2: Attach Strings
Attach equal-length strings at evenly spaced points.



2

3

Step 3: Secure Egg
Attach the egg or water balloon carefully below the canopy.



Step 4: Drop Test
Drop from a fixed height under supervision.

4

5

Step 5: Measure Time
Record descent time using a stopwatch.

Step 6: Compare Results
Slowest safe descent wins.

6

Self-Assessment Trivia

1. What is drag?

A. Force that pulls downward B. Air resistance that slows motion C. Heat energy

2. What helps a parachute slow down descent?

A. Less air B. Large surface area C. Higher speed

3. Larger parachutes create more drag A. True B. False

4. Parachutes increase falling speed A. True B. False

Thinking Questions

1. Why must parachute strings be equal in length?
2. How does canopy shape affect parachute performance?

Observations

Students should observe:

- Larger parachutes fall more slowly.
- Uneven strings cause spinning.
- Heavy materials increase speed.
- Stable designs land upright.

Analysis and Conclusion

The experiment shows that drag increases with surface area, and a balanced design is essential for maintaining stability during flight. Using lightweight materials improves overall performance, while a proper canopy shape ensures that the descent is slowed effectively for a controlled arrival. Parachutes slow descent by significantly increasing air resistance to counteract the pull of gravity. An effective design requires carefully balancing size, shape, and weight to ensure the spacecraft or payload achieves a safe and successful landing.

Did You Know?

Space capsules use multiple parachutes to ensure a safe landing.

Where Else Do We See This Science?

- Skydivers use large canopy parachutes to slow from 200 km/h to a safe landing speed
- Dandelion seeds use feathery structures to catch air and float slowly to new locations
- Military cargo drops use giant parachutes to safely deliver heavy supplies from aircraft
- Drag racing cars deploy rear parachutes to slow down rapidly after a high-speed run

Precautions & Safety

- ⚠ Perform a drop test under teacher supervision.
- ⚠ Use a safe drop height.
- ⚠ Maintain a safe distance during testing.
- ⚠ Clean broken eggs immediately.
- ⚠ Handle scissors carefully.

Answers:- Pre-activity 1.B 2.B, Self assessment 1.B 2.B 3.A 4.B

03 Recovery / Re-entry

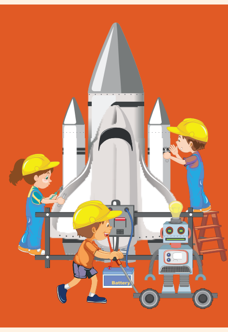
The Fiery Journey Home

3.5 Floating Capsule

To design a capsule model that can safely land on water and float, and to understand the principle of buoyancy.

Objective

a. **To understand why some objects float while others sink.**
b. **To learn the concept of buoyant force.**
c. **To design a stable floating capsule model.**
d. **To relate the activity to real spacecraft splashdown missions.**
e. **To develop design and testing skills.**



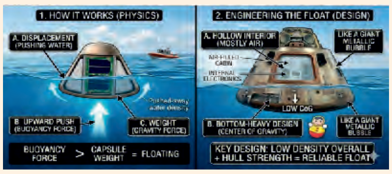
Scientific Foundation

When a spacecraft returns to Earth, the final challenge is the Impact. Even with giant parachutes, a capsule hits the surface at a significant speed. Engineers must find a way to "attenuate" (reduce) this impact force to keep the astronauts safe.

The "Big Blue Cushion": Why Water?

Imagine jumping from a high diving board. Would you rather land on a concrete road or in a swimming pool?

- **The Concrete (Hard Landing):** The surface is rigid. Your body stops instantly. This creates a massive, dangerous force because the energy has nowhere to go.
- **The Water (Splashdown):** Water is a fluid. When the capsule hits, the water molecules move and splash away. This "moving" of water takes time, which means the stop happens gradually.
- **The Physics:** By increasing the time it takes to stop, we decrease the force of the impact. This is called Impact Attenuation.



The Physics of Floating: Buoyancy

Landing in the ocean is only the first step; the capsule must also stay afloat. This is governed by Archimedes' Principle.

- **Buoyancy (The Upward Push):** When a capsule hits the water, it pushes water out of the way (displacement). The water pushes back with an upward force called Buoyancy.
- **Engineering the Float:** Even though capsules are made of heavy metal, they are mostly hollow and filled with air. This makes the overall density of the capsule much lower than water, allowing it to float like a giant metallic bubble.

The "Roly-Poly" Effect: Stability & Center of Gravity

A capsule in the middle of the ocean faces giant waves. If it flips upside down (called a Stable II position), the antennas might be underwater and the door might leak. Engineers prevent this using the Center of Gravity (CoG).

- Bottom-Heavy Design: Engineers place the heaviest equipment-like batteries, oxygen tanks, and the heat shield-at the very bottom of the capsule.
- Self-Righting: This makes the capsule behave like a "Roly-Poly" toy. Because the Center of Gravity is so low, gravity constantly pulls the bottom toward the sea floor. Even if a wave tilts the capsule, it automatically swings back to an upright position.
- The Goal: To ensure the communication antennas stay pointed at the sky and the hatch remains safely above the waterline.

Real-Life Example

Think about a toy that always stands back up when you push it. It has a heavy bottom. Space capsules use the same idea.

Real-World Connection

Space agencies conducts splashdown tests for crew modules in preparation for human space missions. NASA has used ocean landings for missions like Apollo and modern crew capsules. Floating capability is essential for astronaut safety after re-entry.

Pre-Activity Engagement

Estimation Challenge

1. Which object is more likely to float in water?

A. Narrow and heavy B. Wide and light C. Small and dense

2. What helps an object float better?

A. Less water displacement B. More water displacement C. Only weight

Puzzle / Thought Experiment

1. Why do large ships made of metal float, but a small metal ball sinks?

2. If you increase the width of a capsule, how will it affect stability in water?

Quick Demonstration (30–60 sec)

Take two objects:

- A flat container (like a bowl shape)
- A small compact object

Place both in water Ask: “Which one floats better and why?” - Wider object floats more easily Connect: “This is how space capsules are designed for safe water landing”

Lets start with the activity

Materials Required

1) Small plastic cup or container
2) Aluminium foil
3) Thermocol piece
4) Clay (for adding weight)
5) Water tub or bucket
6) Tape
7) Paper and markers

Working Principle

The capsule floats if it displaces enough water to balance its weight.

1. Design a capsule shape.
2. Place it gently in water.
3. Observe whether it floats or sinks.
4. Modify design (increase width or reduce weight) if needed. Students can test stability by gently disturbing the water surface.

(Buoyancy explained)
https://www.youtube.com/watch?v=nMIXU97E-uQ

Procedure

1

Step 1: Design Capsule

- Create a rounded base structure using foil or plastic cup.
- Ensure bottom is wide for stability.

Step 2: Add Weight

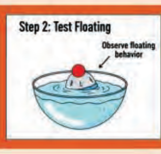
- Place small clay ball inside to represent astronauts

2

3

Step 3: Test Floating

- Place capsule gently in water.
- Observe floating behavior.



Step 4: Improve Design

Adjust shape or weight distribution if it tilts or sinks.

4

Self-Assessment Trivia

1.What helps an object float in water?

A. High speed B. Water displacement C. Air pressure

2. Why is a wide base important for a capsule?

A. To increase weight B. To improve stability C. To reduce height

3. Increasing width can improve floating stability A. True B. False

4. Heavier objects always sink in water A. True B. False

Thinking Questions

1. Why must a space capsule remain stable after landing in water?
2. How does weight distribution affect floating behavior?

Observations

Students should observe:

- Whether the capsule floats or sinks.
- Stability on water surface.
- Effect of adding extra weight.
- Water displacement around the capsule.

Analysis and Conclusion

The experiment demonstrates that objects float when the buoyant force balances their weight, and a wider base significantly increases stability in the water. Even heavy materials can float if they are properly shaped, showing that weight distribution is critical for maintaining an upright and balanced position. Space capsules are carefully designed to float safely after splashdown by using the principle of buoyancy. This engineering ensures that the spacecraft remains stable and upright until the recovery team arrives to retrieve the crew or the payload.

Did You Know?

Apollo astronauts returned to Earth by splashing down in the ocean.

Where Else Do We See This Science?

- Large steel ships float because their hollow hulls displace enough water to stay buoyant
- Life jackets use buoyant foam to keep people afloat and upright in water
- Submarines fill and empty ballast tanks to control whether they sink or rise
- Roly-poly toys always return upright due to a heavy base just like space capsules

Precautions & Safety

- ⚠ Do not overfill water container.
- ⚠ Avoid spilling water on the floor.
- ⚠ Handle clay and foil safely.
- ⚠ Clean water spills immediately.
- ⚠ Teacher supervision recommended.

Answers:- Pre-activity 1. B 2.B , Self assessment 1.B 2.B 3.A 4.B

03 Recovery / Re-entry

The Fiery Journey Home

3.6 Paper Capsule Models

To explore different spacecraft capsule shapes by creating paper cut models and understanding how shape affects re-entry and landing.

Objective

a. **To identify various capsule design types.**
b. **To understand why spacecraft capsules have specific shapes.**
c. **To compare aerodynamic stability of different models.**
d. **To relate capsule shape to heat resistance and safe landing.**
e. **To develop model-making and observation skills.**

Scientific Foundation

Spacecraft do not look like airplanes when they return to Earth. Engineers do not design them to look sleek or cool; they design them to **survive extreme forces and temperature.**

1. Airplane vs. Capsule: The Speed-Heat Conflict

Think about a commercial airplane or the Space Shuttle both have wings and pointed noses because they are designed to fly efficiently in the atmosphere. At speeds around 900 km/h, airplanes use their wings to generate lift and move smoothly through relatively thick air.In contrast, a re-entry capsule travels at extremely high speeds, around 27,000 km/h. At this speed, air gets compressed so intensely that temperatures can reach about 1,600°C. Sharp shapes or wings would concentrate this heat like a needle, causing severe damage or even melting.That's why re-entry vehicles follow a different engineering rule: wings are useful for flying in thick air, but for extreme heat and high-speed braking, a blunt heat shield is much safer and more effective.

2. Form Follows Function: Why a "Blunt" Bottom?

A spacecraft is designed as a capsule a wide, rounded, bell-like structure because its main goal is protection and safe deceleration during re-entry. Engineers deliberately choose a blunt body shape to create the right shock wave that keeps extreme heat away from the vehicle.The capsule has two main parts. The forward side, called the shield face, is the large bottom surface covered with a heat shield that directly faces the intense heat of around 1,600°C. The aft side, or crew face, is the upper bell-shaped section that stays protected behind the shield. This cooler area contains important components like the hatch, parachutes, and antennas.

3. Case Studies in Re-entry Shapes

While all re-entry vehicles use the "Blunt Body" strategy, the specific angles and dimensions are tuned for different mission types.

Mission Era	Design Style	Design Detail
Pioneers(Mercury/Apollo/Orion)	Classic Cone	A steep cone angle. It creates a powerful, compact shock wave. Ideal for returning quickly and directly from the Moon or deep space.
New Era (Gaganyaan/Crew Dragon)	Rounded Bell	A softer cone angle with a more pronounced "bell" curvature. This subtle shape change helps engineers balance interior space and aerodynamic stability slightly differently.
Hypersonic Experiments	Wedge	Some highly advanced, experimental vehicles use subtle flat wedge shapes to generate a tiny amount of lift and maneuver a small distance during re-entry. (But they still maintain that crucial blunt front edge!).

Real-World Connection

ISRO is developing crew capsules for future human space missions. NASA has used capsule designs in missions such as Apollo and modern crew spacecraft. Capsule shape design is critical for astronaut safety during re-entry.

Pre-Activity Engagement

Estimation Challenge

1. Which shape will fall more stable (without flipping)?

A. Conical (pointed) B. Blunt rounded C. Cylindrical

2. Which shape will fall fastest?

A. Flat / blunt B. Pointed C. All same

Puzzle / Thought Experiment

Why do space capsules usually have a blunt (rounded) shape instead of a sharp pointed one?

If an object keeps flipping while falling, is it stable or unstable? Why?

Quick Demonstration (30–60 sec)

Take two paper shapes:

- Flat sheet
- Slightly curved/rounded paper

Drop both Ask:"Which one falls more steadily?"

A rounded/structured shape is more stable

Lets start with the activity

Materials Required

1) Chart paper
2) Scissors
3) Glue or tape
4) Pencil
5) Ruler
6) Small clay piece (for weight testing)

Working Principle

This activity compares different shapes:

1. Conical (pointed) shape
2. Blunt rounded shape
3. Cylindrical shape

Students drop models from a small height and observe:

- Stability during fall
- Speed of descent
- Orientation while falling

Blunt models generally show better stability and controlled descent.

(The science of Re-entry)
https://www.youtube.com/watch?v=9Vl6o85QGDg

Procedure

1 **Step 1: Create Different Shapes**
- Cut and assemble at least two different capsule shapes.

2 **Step 2: Add Weight**
- Place small clay piece inside for stability.

3 **Step 3: Drop Test**
- Observe how they fall.

4 **Step 4: Compare**
- Record differences in stability and speed.

Self-Assessment Trivia

1. Which shape provides better stability during fall?

A. Sharp pointed B. Blunt rounded   C. Random shape

2.What does stability mean in this experiment?

A. Faster fall B. Controlled and steady motion   C. Heavier object

3. Shape affects how an object falls   A. True B. False

4. All shapes fall in the same way   A. True B . False

Thinking Questions

1. Why does a blunt shape provide better control during descent?
2. How can adding weight improve stability while falling?

Observations

Students should observe:

- Which model falls straight_______
- Which model tumbles_______
- Difference in falling speed_______

Analysis and Conclusion

The activity demonstrates that blunt shapes provide superior stability during a fall, whereas pointed shapes are more likely to tumble. A wider base also increases air resistance, which effectively slows the descent and ensures a more controlled path toward the ground. A capsule's shape plays a major role in ensuring safe atmospheric re-entry and a successful landing. Blunt body designs are specifically engineered to help reduce intense heating and improve flight stability, making them essential for protecting spacecraft during the final stages of a mission.

Did You Know?

Blunt-shaped space capsules are safer than sharp ones during re-entry.

Where Else Do We See This Science?

- Badminton shuttlecocks always fly cork-first because the heavy end leads naturally
- Arrows and darts are heavier at the front to stay stable and pointed during flight
- Racing car nose cones are rounded and tested in wind tunnels to manage air pressure
- Delivery drones use stable aerodynamic shapes to maintain correct orientation mid-flight

Precautions & Safety

- ⚠ Use scissors carefully.
- ⚠ Avoid dropping models from excessive height.
- ⚠ Ensure clear drop area.
- ⚠ Handle clay safely.
- ⚠ Teacher supervision recommended.

Additional Links

(The Engineering of Re-entry):
https://youtu.be/ivLX9o6Ayl8?si=fNxwo3eBldn1w_S3

(SpaceX Starship Re-entry) :
https://youtube.com/shorts/Fdj2KvaOd2I?si=r5OFsa0YrROfALPQ

Answers:- Pre-activity 1. B 2.B   Self assessment Trivia -1.B 2.B 3.A 4.B

04 Ground Segment

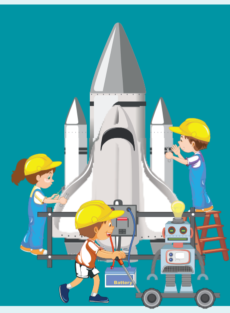
Mission Control & Communication

4.1 Paper Cup & Walkie-Talkie

To understand the basic principles of communication by building a simple paper cup communication model and relating it to space communication systems.

Objective

a. **To understand how sound travels through different medium.**
b. **To demonstrate vibration-based sound transmission.**
c. **To compare mechanical communication and radio communication.**
d. **To relate the activity to satellite-ground communication.**
e. **To develop teamwork and practical skills.**



Scientific Foundation

A satellite in space does not make its own decisions. It functions like a character in a video game it moves and acts only because someone on Earth is holding the "controller." This entire system of controlling and communicating with a satellite is called the Ground Segment.

The Three Functional Parts of a Ground Station

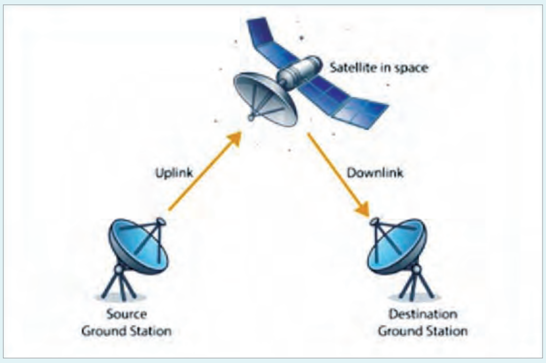
To manage a satellite from millions of kilometers away, we use a global network that acts like its eyes, ears, and brain. The antennas serve as the eyes, using large dish structures to send and receive signals to and from space. The receivers act as the ears, converting these radio signals into meaningful digital data. Finally, the Mission Control Center (MCC) works as the brain, where engineers and the flight director monitor the satellite's condition and make important decisions to ensure mission success.

Telemetry: The Satellite's Health Report

Engineers determine whether a satellite is "healthy" by monitoring its telemetry, which is a real-time digital report sent from space to the Mission Control Center (MCC). This data includes key information such as battery level (e.g., "power is at 80%"), temperature (e.g., "camera is at -10°C"), and orientation (e.g., "tilted slightly to the left"). If telemetry indicates any issue, engineers can immediately send commands back to the satellite, such as instructing it to shut down a system temporarily to save energy or prevent damage.

Uplink & Downlink: A Two-Way Street

Since wires cannot be used in space, communication is done using radio waves. These waves travel at the speed of light (about 300,000 km/s) and do not require air to propagate. Communication happens in two ways: uplink and downlink. Uplink is when commands are sent from Earth to the satellite, such as instructing it to rotate its solar panels toward the Sun. Downlink is when the satellite sends data like images or scientific information back to Earth. Because satellites have limited power, their signals are very weak, which is why large and highly sensitive ground antennas are required to receive them.



Real-World Connection

Space agencies uses ground stations to communicate with satellites using radio signals and operates deep space communication networks to send and receive signals from spacecraft.

Astronauts communicate with mission control using radio waves, not sound waves.

Pre-Activity Engagement

Estimation Challenge

1. Can sound travel without any material (air, string, etc.)?

A. Yes B. No C. Sometimes

2. When will sound be heard clearly?

A. Loose string B. Tight string C. No string

Puzzle / Thought Experiment

If there is no air or medium, can we hear sound? Why?

Why can astronauts not hear each other directly in space without communication devices?

Quick Demonstration (30–60 sec)

Ask a student to speak from a distance. Then ask them to speak through a table (tap sound) Ask: "What changed?" -Sound travels better through a medium. Connect: "Sound needs a medium to travel"

Lets start with the activity

Materials Required

1. 2 Paper Cups
2. A long piece of String (5–10 meters)
3. 2 Paper Clips
4. A sharpened Pencil
5. 2 Walkie-Talkies
6. A Mission Log Sheet

Working Principle

The model works on the principle of sound vibration transmission through solids.

1. Speak into one cup.
2. Sound waves create vibrations in the cup base.
3. Vibrations travel along the stretched string.
4. The second cup vibrates and reproduces sound.

The string must be tight for effective communication.

(How do cans work as a telephone)

https://www.youtube.com/watch?v=mb4c-kOVTtA

Procedure

Activity 1 - The Acoustic Telephone

(Understanding Why Sound Needs a Medium)

Step 1: Use the pencil to make a small hole at the bottom of each cup. Pass the string through both cups and tie the ends with paper clips so **that the** string stays in place.

Step 2: Two students hold the cups and move apart until the string is completely tight. Make sure the string is not loose and does not touch any surface.

Step 3: One student speaks softly into the cup while the other student listens by placing the cup close to their ear.

Step 4: While speaking, gently touch the string and feel the vibrations traveling through it.

Step 5: Now make the string loose and repeat the activity. Observe that the sound becomes weak or cannot be heard clearly.

Procedure

Activity 2 - The Wireless Space Link
(Simulating Satellite Communication)

1. **Step 1:** Assign one student as the Ground Station (inside the classroom) and another as the Satellite (outside the classroom or far away).
2. **Step 2:** Give both students walkie-talkies for communication. The Ground Station keeps a Mission Log to record messages.
3. **Step 3:** The Ground Station sends a command, for example: "Ground Station to Satellite: Status check. Over."
4. **Step 4:** The Satellite receives the message and replies, for example: "Satellite to Ground Station: All systems are working. Battery is at 80%. Over."
5. **Step 5:** Now move the Satellite farther away or behind a wall. Observe how the signal becomes weak, unclear, or produces static noise.

Self-Assessment Trivia

1. **What is required for sound to travel?**
   A) Vacuum B) Medium C) Light D) Heat
2. **In the paper cup experiment, sound travels through the string as:**
   A) Light waves B) Electrical signals C) Mechanical vibrations D) Magnetic waves
3. **Sound can travel in vacuum.** A. True B. False
4. **Walkie-talkies use sound waves through air only.** A. True B. False

Thinking Questions

1. Why do astronauts use radios instead of speaking directly in space?
2. What is the difference between uplink and downlink?

Observations

Students should observe:
- Clear sound when string is tight.
- Weak or no sound when string is loose.
- Students observe that paper-cup phone fails without string.
- Students observe that walkie-talkie works even through walls.
- Students notice that wireless communication does not need physical connection.

Analysis and Conclusion

The experiment demonstrates that sound travels as vibrations, which are transmitted most effectively through solids. Maintaining tension in the string significantly improves sound clarity, showing how physical mediums allow mechanical waves to move from one point to another. Communication requires a medium for transmitting sound waves, but since sound cannot travel in the vacuum of space, missions must use electromagnetic radio waves instead. This shift in technology allows ground stations to stay connected with satellites across the vast emptiness of the solar system.

Did You Know?

Sound cannot travel in space because there is no air

Where Else Do We See This Science?

- FM radio stations broadcast voice as radio waves, received by antennas in your radio or phone
- Army soldiers use walkie-talkies for field communication using the same uplink-downlink principle
- Ships communicate with ports using radio waves since sound cannot travel across vast ocean distances
- Pilots receive landing instructions from air traffic control entirely through radio wave communication

Precautions & Safety

- ⚠ Handle needle carefully.
- ⚠ Do not pull string too hard.
- ⚠ Avoid running while holding cups.
- ⚠ Ensure safe distance between students.
- ⚠ Teacher supervision recommended.

Answer:- Pre-Activity Engagement 1. B 2. B, Self-Assessment 1. B 2. C 3. B 4. C

04 Ground Segment

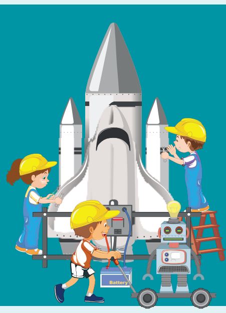
Mission Control & Communication

4.2 Tape Measure Antenna

To construct a simple antenna model using a measuring tape (or metal strip) and understand how antennas receive signals.

Objective

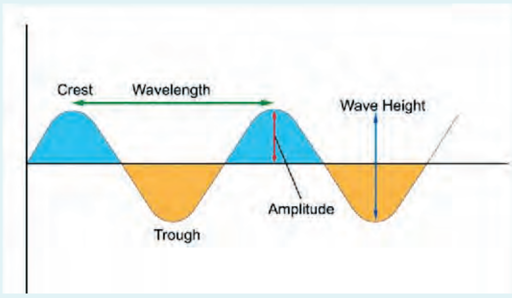
a. **To understand the basic concept of electromagnetic waves.**
b. **To learn how antennas receive radio signals.**
c. **To observe the relationship between antenna length and signal reception.**
d. **To relate antenna design to satellite communication systems.**
e. **To develop practical model-building skills.**



Scientific Foundation

Before we understand how an antenna works, we need to understand the "language" of space signals. These signals travel like invisible waves in an ocean.

Imagine you are at a beach watching waves hit the shore. To understand these waves, we look at two things:



1. Wavelength (The "Size" of the Wave)

Wavelength is the distance between the top of one wave and the top of the next one.

- Think of it as the "Step Length" of the wave.
- Just like a tall person takes long steps and a small child takes short steps, different signals have different step lengths (Wavelengths).

2. Frequency (The "Speed" of the Wave)

Frequency is how many waves hit the shore in one minute.

- If waves hit very fast, it is High Frequency.
- If waves hit slowly, one by one, it is ***Low Frequency.***

The Secret Rule: If the steps are long (Long Wavelength), the waves hit slowly (Low Frequency). If the steps are tiny (Short Wavelength), the waves hit very fast (High Frequency).

Superman's Ears – Why Antennas Exist

Imagine someone in Delhi whispers your name while you are in Ludhiana. You cannot hear them. But a Ground Station can hear a tiny beep from a satellite hundreds of kilometers away.

How? Through an Antenna.

- An antenna acts as the "Ears" and "Mouth" of a computer.
- It "catches" those invisible waves and converts them into tiny Electrical Signals (small currents inside wires).

The Science of Resonance: Why Size Matters

This is the most important part! Why is a phone antenna small but a TV antenna big?

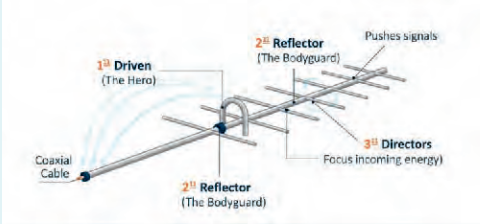
The Playground Swing Analogy: Think of a swing. If you push it at the exact right time (its natural rhythm), it goes higher. If you push too early or too late, it slows down.

Antennas have a natural rhythm too.

- To catch a signal perfectly, the **Length of the Antenna must match the Wavelength (Step Length)** of the signal.
- When they match perfectly, it is called Resonance.

- **Antenna too short:** It misses the wave.
- **Antenna too long:** It wastes energy.
- **Perfect length:** You get a crystal-clear signal!

This is why we use a **Carpenter's Measuring Tape.** Since it's made of metal, we can pull it out to the exact "Resonance" length needed to talk to a satellite.



The Yagi-Uda Antenna: The Flashlight Effect

Usually, an antenna sends signals everywhere, like a **Light Bulb.** But for satellites, we need to focus the signal in one direction, like a **Flashlight.** We use a **Yagi-Uda Antenna** for this.

It has three main parts:

1. **Driven Element:** The "Heart" of the antenna that actually sends and receives the signal.
2. **Reflector:** A slightly longer rod at the back that pushes the signal forward (like the mirror inside a flashlight).
3. **Directors:** Shorter rods at the front that "point" the signal toward the satellite.

Real-World Connection

Space agencies operates large ground antennas to communicate with satellites and deep-space missions and uses large dish antennas in its Deep Space Network to receive signals from distant spacecraft.

Antennas are essential for satellite TV, GPS, mobile phones, and space exploration.

Lets start with the activity

Pre-Activity Engagement

Estimation Challenge

What helps in getting a clear radio signal?

A. Random metal piece
B. Proper antenna size and direction
C. No antenna

What happens if antenna alignment is wrong?

A. Signal improves
B. Signal becomes weak
C. No change

Puzzle / Thought Experiment

If the antenna length is too small or too large, will it receive signals properly? Why?

Why do TV and radio antennas have fixed shapes and sizes?

Quick Demonstration (30–60 sec)

Turn on an FM radio Move the antenna in different directions

Ask:"What happened?"- Signal changes (strong/weak)
Connect:"Antenna size and direction affect signal reception"

Materials Required

1) Flexible steel measuring tape
2) PVC pipe (1 m)
3) Coaxial cable
4) Zip ties / tape
5) Soldering iron or screws

Safety: Tape sharp edges immediately.

Working Principle

The metal strip acts as a simple antenna that receives radio waves from the air. When these waves hit the metal, they create small electrical currents that help improve signal reception. By changing the length and direction of the strip, the antenna can capture signals more effectively.

This experiment shows that proper size and orientation of an antenna are important for getting clear signals, just like in real communication systems.

(Working of Antenna)
https://www.youtube.com/watch?v=ZaXm6wau-jc

Procedure

Activity 1 – Making the Meter Tape Yagi

To build a 137 MHz directional satellite antenna using scrap materials.

Cut Elements

- Reflector → 109 cm
- Driven element → two pieces of 53 cm
- Director → 90 cm

Fix on PVC Boom

- Reflector at back
- Driven element 45 cm ahead
- Director another 45 cm ahead

Wire Connection

- Inner copper → one driven side
- Outer shield → other side

Observations

Students observe that precise measurement improves signal.
Misaligned elements reduce reception.

Activity 2 – Testing & Polarization (Steps)

Step 1 – FM Signal Test

- Tune the FM radio to a station.
- Connect the antenna and observe the sound.
- Disconnect the antenna and compare the signal quality.

Step 2 – Wrist Rotation (Polarization Test)

- Hold the antenna horizontally and observe signal strength.
- Rotate the antenna to vertical and note the change.

Step 3 – Satellite Tracking

- Point the antenna toward the sky.
- Move it slowly along the satellite path.
- Observe changes in signal strength and spikes.

Self-Assessment Trivia

1. What type of waves do antennas receive?

A) Sound waves B) Water waves C) Electromagnetic waves D) Heat waves

2. What happens when antenna length matches wavelength?

A) Signal disappears B) Resonance occurs C) Heat increases D) Noise increases

3 . Antennas need air to receive signals. - A. True B. False

4. Bigger antenna always means better signal. - A. True B. False

Thinking Questions

1. Why did rotating the antenna change the signal strength?
2. Why is precise measurement important in antenna design?

Observations

Students should observe:

- Precision is Key: Even a few centimeters of error in antenna length or a loose wire can cause the entire signal to fail.
- Antenna Power: Without an antenna, the receiver only hears static; the antenna is the "mouth and ears" that catches invisible radio waves.
- Invisible Direction: Through the "Wrist-Twist" test, we saw that radio waves vibrate in specific directions (Polarization), not randomly.
- Moving Targets: Satellites are not fixed in the sky; we must actively track their movement to keep a strong signal.
- Science over Magic: Space communication is a perfect mix of math, physics, and careful engineering, not just luck.

Analysis and Conclusion

The experiment demonstrates that antenna length and orientation play an important role in signal reception, as metal conductors are designed specifically to capture electromagnetic waves. Proper antenna design and precise alignment significantly improve communication by ensuring that signals are captured clearly without interference.

Antennas work by converting electromagnetic waves into electrical signals that can be processed by ground systems. Using the correct size and alignment is essential for efficient communication with satellites, ensuring that data is transmitted and received successfully across long distances.

Did You Know?

Some deep-space antennas can be over 70 meters wide.

Where Else Do We See This Science?

- Dish antennas on rooftops capture satellite TV signals using the same resonance principle
- Wi-Fi routers use internal antennas precisely sized to match their transmission frequency
- MRI machines use carefully tuned antenna coils to detect radio signals from inside the human body
- NASA's Deep Space Network uses giant 70-metre antennas to catch faint signals from distant spacecraft

Precautions & Safety

⚠ Do not connect to high-voltage sources.
⚠ Use only battery-operated radio.
⚠ Handle measuring tape carefully (edges may be sharp).
⚠ Avoid stretching tape forcefully.
⚠ Teacher supervision recommended.

Additional Links

(Tape Measure Antenna Procedure)
https://www.instructables.com/The-Tape-Measure-Antenna/

Answer: Answers;-Pre-activity 1. B. 2. B., self assessment 1. C 2. B 3.B 4. B

04 Ground Segment

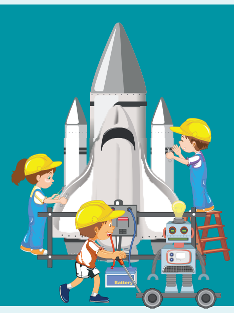
Mission Control & Communication

4.3 Morse Code Communication

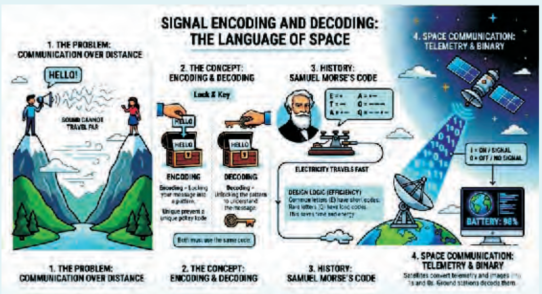
To understand basic signal encoding and decoding by transmitting names using Morse code through light and sound.

Objective

a. **To learn what Morse code is.**
b. **To understand how information can be encoded into signals.**
c. **To practice transmitting and decoding simple messages.**
d. **To relate signal coding to space communication systems.**
e. **To develop listening, observation, and teamwork skills**



Scientific Foundation



Imagine standing on two distant mountain peaks. If you shout to a friend on the other side, your voice will fade due to the wind and the vast distance.

- **The Reality:** Human voice cannot travel very far on its own.
- **The Solution:** To communicate across long distances, we must convert our message into a Signal (such as light flashes, electrical pulses, or radio waves).

The Concept: Encoding and Decoding

Think of this process as a Lock and Key system. For a message to travel, it must be "locked" into a code and "unlocked" at the destination.

Encoding (The Lock)

Encoding is the process of converting information into a specific pattern or code.

- Example: 1 Flash of a torch = "YES"; 2 Flashes = "NO".

Decoding (The Key)

Decoding is the process of looking at the received pattern and translating it back into its original meaning.

- Example: Seeing 2 flashes and understanding it means "NO".

Important Rule: Both the sender and the receiver must use the same "Codebook." If they use different codes, the communication fails.

History: Samuel Morse and the Birth of Data

About 180 years ago, Samuel Morse realized that while voice cannot travel through wires, electricity can. He invented Morse Code, which uses two simple building blocks:

- **Dot (•):** A short electrical pulse.
- **Dash (—):** A long electrical pulse.

Design Logic (Efficiency)

Morse was clever. He gave common letters (like 'E') a very short code (•), and rare letters (like 'Q') a longer code (— — • —). This is called Efficiency—sending the most information in the shortest amount of time. This same logic is used by the modern internet today.

Space Communication: Telemetry and Binary

Satellites do not "speak" human languages. They communicate using Binary Code, a system based on only two numbers: 1 and 0.

- **1 = ON** (Signal present)

- **0 = OFF** (No signal)

Whether a satellite is sending a high-resolution photo of Mars or reporting its battery temperature (Telemetry), it converts everything into long sequences of 1s and 0s. Computers on Earth then Decode these numbers back into the images and data we see on our screens.

Real-World Connection

Space agencies sends encoded digital signals between satellites and ground stations and communicates with spacecraft using radio signals encoded into digital data.

All modern communication systems including space missions rely on encoding and decoding signals.

Lets start with the activity

Pre-Activity Engagement

Estimation Challenge

How can we send a message without speaking?

A. Using light
B. Using only writing
C. Not possible

What happens if something blocks the light?

A. Message becomes faster
B. Message stops
C. No effect

Puzzle / Thought Experiment

If you shine a torch toward your friend and someone stands in between, will your friend receive the signal? Why?

Why do satellites need a clear path (line of sight) to communicate?

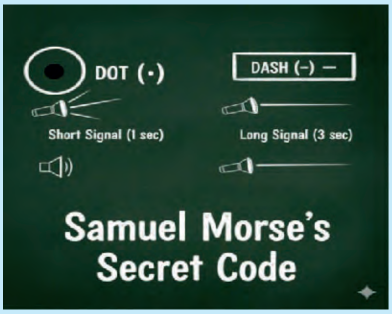
Quick Demonstration (30–60 sec)

Turn on a torch and point it toward a wall

Now place your hand in between

Ask:"What happened?" -Light is blocked Connect: "Communication stops if path is blocked"

1) Torch / Flashlight
2) Morse Code chart
3) Notebook and pen
4) Spoon and glass / Buzzer



Procedure

Activity 1 – Operation Lighthouse

Talking with Light (Optical Communication)

1. Divide class into two teams.
2. Team A writes a secret word.
3. Convert each letter into Morse code.
4. Team A flashes torch using dots and dashes.
5. Team B watches and writes pattern.
6. Team B uses chart to decode letters.

Observations

Students notice:

- Wrong timing changes meaning.
- Clear pauses between letters are important.

Scientific Explanation

Light travels in straight lines.
If something blocks the light, communication stops.
This is called **line of sight.**
Satellites also require clear line of sight.

Activity 2 – The Spy Telegraph
Sound-Based Decoding

Procedure

1. Teacher selects a word.
2. Teacher taps dots and dashes.
3. Students write patterns.
4. Students decode word.

Observations

Students notice:

- Fast signals are hard to catch.
- Repetition helps accuracy.

Self-Assessment Trivia

1. **What is required for light communication?**
   A. Noise   B. Line of sight   C. Heat
2. **What happens if timing is wrong in Morse code?**
   A. No change   B. Message changes   C. Faster signal
3. **Light can bend around objects easily** - A. True B. False
4. **Clear path is needed for light communication** - A. True B. False

Thinking Questions

1. Why did rotating the antenna change the signal strength?
2. Why is precise measurement important in antenna design?

Analysis and Conclusion

The activity demonstrates that information can be effectively transmitted using coded signals, provided there is clear encoding and precise timing to maintain accuracy. Effective communication systems rely on both the sender and the receiver having a shared understanding of the specific code being used.

Signal encoding and decoding are fundamental to both space communication and modern digital systems. Just as in the activity, today's satellites use advanced digital versions of these encoding methods to ensure that complex data is sent and received without errors across deep space.

Did You Know?

SOS in Morse code is ••• —— •••.

Where Else Do We See This Science?

- Binary code in all computers uses only 0 and 1 — a direct evolution of Morse's dot-dash idea
- QR codes encode information into black-and-white patterns that scanners instantly decode
- Braille encodes letters as raised dot patterns, read by touch instead of sight
- Emergency SOS signals use three short, three long, three short flashes — pure Morse code

Precautions & Safety

⚠ Do not flash torch directly into eyes.

⚠ Maintain clear line of sight.

⚠ Keep noise levels controlled during sound transmission.

⚠ Ensure fair participation.

⚠ Teacher supervision recommended.

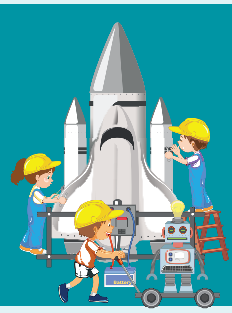
Answers:-Pre-activity engagement 1. A. 2. B, Self assessment Trivia 1. B. 2. B. 3. B 4. A

4.4 Drone View Drawing

To understand aerial imaging and mapping by drawing a top (bird's-eye) view of the school as seen from a drone.

Objective

a. **To understand the concept of aerial view and mapping.**
b. **To learn how satellites and drones capture images.**
c. **To observe spatial arrangement of buildings and open areas.**
d. **To develop scale drawing and observation skills.**
e. **To relate the activity to satellite remote sensing.**



Scientific Foundation

When you walk through your school corridors, you see doors, trees, and classrooms. This is an **"Ant's View"**—you see things from the ground level.

Now, imagine flying high above the school like an eagle. Suddenly, you can see the entire school boundary, the shape of the buildings, and the layout of the playground. This is **Earth Observation.** By using drones and satellites, scientists gain this "Eagle's View" to study our planet from above.

Understanding the "Nadir View" (Top-Down View)

In Earth Observation, the angle of the camera matters. We generally use two types of views:

- **Side View (Perspective):** Like a selfie or a photo of a building's face. It shows height and depth.
- **Nadir View (Top View):** The camera points straight

Why is Nadir View important?

Engineers and scientists cannot map cities using selfies. They need the Nadir View because it provides:

1. Accurate Measurements: Distances between points are easy to calculate.
2. Clear Boundaries: It shows the exact shapes of roads, roofs, and land.
3. Mapping: It is the foundation for all modern GPS and satellite maps.

What is Remote Sensing?

The technology used in Earth Observation is called **Remote Sensing.**

- **Remote:** Means "from a distance."
- **Sensing:** Means "collecting information."

Just as your eyes "sense" light from a distance without touching an object, satellites and drones collect data about Earth's surface from high in the sky.

The Drone: A "Mini-Satellite"

A drone is essentially a small-scale version of a space satellite. They share the same basic components:

Feature	Satellite Version	Drone Version
Structure	Satellite Body	Drone Frame
Data Collector	High-tech Sensor	Digital Camera
Communication	Ground Station (Dish)	Remote Controller

Ground Applications: Solving Real-World Problems

We don't just take photos for fun; we use this "Aerial Data" to solve problems on Earth:

- **Agriculture:** Farmers use images to check if crops are healthy or need water.
- **Urban Planning:** City planners use top-view maps to design new roads and parks.
- **Disaster Management:** After a flood or earthquake, drones locate damaged areas quickly.
- **Environment:** Forest officers monitor "Deforestation" (cutting of trees) from above.

Resolution: Detail vs. Area

The quality of an image depends on how high we fly:

- **Drones (Low Altitude):** Provide **High Resolution.** You can see individual plants or small cracks in a road, but they cover a small area.
- **Satellites (High Altitude):** Provide a **Lower Resolution** but cover an entire country or continent in a single shot.

Real-World Connection

Space agencies uses Earth observation satellites to capture high-resolution images for mapping and disaster management.They use remote sensing satellites to study climate, forests, oceans, and cities.

Satellite images are used in Google Maps, weather forecasting, and urban planning.

Pre-Activity Engagement

Estimation Challenge

How do you think maps are created?

A. By drawing randomly
B. By looking from the top
C. By guessing

Which view gives more accurate information?

A. Side view
B. Top view
C. Front view

Puzzle / Thought Experiment

If you stand on the ground, can you see the full layout of your school? Why or why not?

Why do satellites and drones capture images from above instead of from the side?

Quick Demonstration (30–60 sec)

Place a book on the table Ask students to look from the side → limited view Now ask them to stand and look from top. Ask:"What changed?" -More area is visible from top

Connect: "This is how maps are created using top view images"

Lets start with the activity

Materials Required

1) Drone image
2) Paper
3) Pencil
4) Ruler
5) Colors
6) RC Drone with camera

Procedure

Activity 1 – Capturing the Data

Disclaimer: Before flying drone make sure to go throught the guidelines provided by government and follow that
https://static.pib.gov.in/writereaddata/specificdocs/documents/2022/jan/doc202212810701.pdf

Safety Precautions

- Keep distance from propellers.
- Fly only in calm weather.
- Keep drone within visual range

1

Pre-Flight Check

- Check Battery levels (Drone & Remote).
- Remove the Gimbal Cover (Camera cap).
- Place the drone on a flat surface (Helipad).

2

Take Off

- Action: Teacher/Student pilot pushes the throttle up.
- The drone rises to a safe altitude (approx. 30-50 meters) until the whole school is visible.

3

The "Nadir" Tilt

- Normally, the camera looks forward.
- Action: Use the scroll wheel on the remote to tilt the camera 90° Down.
- Now, look at the screen. You are seeing the "Top View."

4

Data Capture

- Adjust the position so the whole school boundary fits in the screen.
- Click: Press the Shutter button to take a photo.
- Video: Record a 10-second video while slowly rotating the drone.

5

Landing

- Bring the drone down slowly and land safely.

Procedure

1

Observation

- Zoom into the drone photo.
- Identify the **School Boundary** (The outer wall).
- Identify the **Building Shape** (Is it a Square, L-shape, or U-shape?).
- Find the "hidden" things: Water tanks on the roof, solar panels, or the pattern of the tiles.

2

Drawing the Outline

- On your paper, draw the boundary wall first (The Frame).
- Draw the main building shape in the center. Remember: **Only draw the Roof.** Do not draw windows!

3

Adding Features

- **Green Areas:** Look at the photo. Where are the trees? Draw green circles there.
- **Grey Areas:** Where is the road/pathway? Draw parallel lines.
- **The Playground:** Draw the shape of the court.

4

Labeling

- Mark the directions (North is usually "Up" in the photo).
- Label "Main Gate," "Assembly Area," and "Classroom Block."

North, Gate, Blocks, Playground.

Self-Assessment Trivia

1. **What type of view is used to create maps?**
   A. Front view B. Top view (Nadir view) C. Side view
2. **What is the first step in making a map from an image?**
   A. Coloring B. Observation C. Labeling
3. **Maps are made using top-view images** - A. True B. False
4. **Side view is best for mapping** - A. True B. False

Thinking Questions

1. Why is it important to capture the full boundary in the drone image?
2. How does a top view help in better planning and understanding of an area?

Observations

Students observe:

- Buildings have hidden shapes.
- Roof objects are visible.
- More open land than expected.
- Maps show information differently than photos.
- Students realize top-view reveals patterns invisible from ground.

Analysis and Conclusion

the activity demonstrates that a top view provides a much clearer understanding of spatial arrangement and the relationship between different objects. effective mapping relies on maintaining proper scale and proportion, similar to how satellite imaging captures Earth's surface using advanced sensors to provide accurate data.

aerial mapping is a vital tool for urban planning, disaster management, and environmental monitoring across the globe. by practicing drawing a top view, students build a foundational understanding of remote sensing, learning how to interpret and analyze the world from a satellite's perspective.

Did You Know?

Satellites can capture detailed images of Earth from hundreds of kilometers above.

Where Else Do We See This Science?

- Google Maps uses satellite and drone aerial images to build accurate street and terrain maps
- Farmers use drone top-view images to spot dry patches and plan irrigation efficiently
- Disaster relief teams use aerial footage to quickly assess flood or earthquake damage
- Archaeologists use drone photography to discover and map buried ruins without any digging

Precautions & Safety

⚠ Ensure safe movement while
⚠ observing campus.
⚠ Avoid restricted areas.
⚠ Maintain discipline during outdoor observation.
⚠ Use drawing tools carefully.
⚠ Teacher supervision recommended.

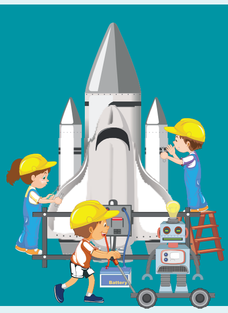
Answer:- Pre-activity 1. B 2.B, Self assessment Trivia -1. B 2. B 3. A 4.B

4.5 Team Building Mission Games

To understand the importance of teamwork, coordination, and communication in space missions through interactive mission-based activities.

Objective

a. **To understand the role of the Mission Control Center (MCC).**
b. **To develop teamwork and leadership skills.**
c. **To practice communication under structured rules.**
d. **To simulate mission planning and execution.**
e. **To improve problem-solving and coordination skills.**



Scientific Foundation

Imagine driving a car on a highway. If the engine overheats or a tire goes flat, you simply pull over to the roadside and call for a mechanic.

In Space, there are no roadsides. At an altitude of 400 km, there are no repair shops, no mechanics, and no second chances. A single loose screw or a 1% drop in oxygen can lead to a catastrophic failure. This is why the Mission Control Center (MCC) is essential. It is the "Zero Error" zone where every heartbeat of the spacecraft is monitored.

Why is MCC So Important?

The MCC acts as the Brain and Heart of the mission. Every flickering number on a controller's screen represents a life-critical factor:

- Life Support: Monitoring oxygen levels and cabin pressure.
- Vehicle Health: Checking battery voltage and engine temperature.
- Navigation: Tracking the exact speed and trajectory of the rocket.

If the MCC detects a problem before the astronauts do, they can solve it from Earth, saving billions of rupees and, more importantly, the lives of the crew.

The Vital Signs: What are they watching?

- Every controller sits at a "Console" (a specialized desk with multiple screens). They aren't just looking at pictures; they are looking at Telemetry—real-time data sent from the rocket.
- Environmental Control: Monitoring the "Air" the astronauts breathe.
- Power Systems: Ensuring the solar panels are charging the batteries.
- Thermal Control: Space is extremely cold in the shadow and boiling hot in the sun. MCC manages the heaters and coolers to keep the cabin comfortable.

The Flight Core: Who is in Charge?

A mission is a giant team effort. Each "Seat" in the room has a specific call sign:

- **FLIGHT (The Flight Director):** The ultimate leader. They have the "Red Button" authority to continue or abort a mission. They lead the team through crises with a calm voice.
- **FIDO (Flight Dynamics Officer):** The math expert. FIDO plots the "Roadmap" in space. If the rocket is off-course by even one degree, FIDO corrects the path.
- **CAPCOM (Capsule Communicator):** The voice of Earth. To avoid confusing the astronauts with too many voices, only the CAPCOM speaks to them. They act as the bridge between the room full of scientists and the crew in space.
- **EECOM (Electrical, Environmental & Consumables):** The "Life Support" specialist. They manage the oxygen, water, and electricity—the things humans need to survive.

Real-World Connection

ISRO operates mission control centers to manage satellite launches and operations.
NASA has a famous Mission Control Center in Houston that manages human spaceflight missions.
Large teams coordinate every stage of space missions from launch to landing.

Pre-Activity Engagement

Estimation Challenge

1. What do you think is more important for mission success?

A. Speed
B. Communication
C. Individual work

2. If everyone talks at the same time, what will happen?

A. Faster work
B. Confusion
C. No effect

Puzzle / Thought Experiment

If a team has very skilled members but poor communication,will they succeed or fail? Why?

Why do real missions have fixed roles instead of letting everyone do everything?

Quick Demonstration (30–60 sec)

Ask 3–4 students to solve a small task together

Allow everyone to speak at the same time

Ask: "What happened?" -Confusion, overlapping instructions Now repeat with one person giving instructions - Task becomes easier

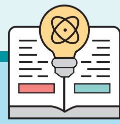
Connect: "Structured communication improves efficiency"

Lets start with the activity

Materials Required

1) Mission role cards Commander, Engineer, Communicator, Scientist)
2) Stopwatch
3) Paper and pen
4) Simple task sheets
5) Whistle or bell

Working Principle



The activity simulates mission operations:

1. Divide students into teams.
2. Assign each member a role.
3. Provide a mission challenge (e.g., solve a puzzle, build a small structure, decode a message).
4. Only the assigned communicator can speak to other teams.
5. Time-bound completion required.

This demonstrates how structured communication improves efficiency.

Procedure

1. **Team Formation**
   - Divide the class into groups of 4–5 students.

2. **Assign Roles**
   - Commander (decision maker)
   - Engineer (builder/problem solver)
   - Communicator (speaks externally)
   - Scientist (analyzes data)

3. **Mission Challenge**
   - Give a specific task (e.g., build the tallest paper tower in 5 minutes).

4. **Communication Rules**
   - Only Communicator can talk between teams.
   - Others communicate within the team only.

5. **Evaluation**
   - Observe teamwork, speed, and coordination.

Self-Assessment Trivia

1. **Who is responsible for communication between teams?**
   A. Engineer B. Commander C. Communicator
2. **What improves team performance the most?**
   A. Noise B. Clear roles and communication C. Random decisions
3. **Everyone speaking at once improves efficiency** - A. True B. False
4. **Defined roles help in better coordination** - A. True B. False

Thinking Questions

1. Why is it important to limit communication to one person?
2. How did roles help your team complete the task faster?

Observations

Students should observe:

- Effect of clear communication.
- Leadership styles within teams.
- Challenges faced during coordination.
- Time management differences.

Analysis and Conclusion

The activity demonstrates that clear role distribution significantly improves efficiency, while maintaining communication discipline effectively reduces confusion during high-pressure tasks. Strong team coordination is essential for mission success, as the quality of leadership and planning directly affects the outcome.

Space missions require exceptional teamwork and structured communication, much like the simulated mission challenge completed in class. By following a clear hierarchy and protocol, teams can solve complex problems and ensure that every system—and every person—is working toward the same goal.

Did You Know?

Deep space missions can have communication delays of several minutes.

Where Else Do We See This Science?

- Hospital emergency teams assign fixed roles and use precise communication to save lives quickly
- Cockpit crews follow strict role-based checklists and protocols before every single flight
- Firefighting teams use command hierarchies to coordinate safely inside burning buildings
- Cricket teams assign specific batting, bowling, and fielding roles to win as a coordinated unit

Precautions & Safety

⚠ Maintain discipline during activities.

⚠ Avoid running or pushing.

⚠ Ensure fair participation.

⚠ Follow time limits strictly.

⚠ Teacher supervision required.

Additional Links

(Apollo 11 Landing)
https://youtu.be/bYMHAWAK7hk?si=oEo6w9Ms7_UJ_3rO

(Inside Mission Control)
https://youtu.be/KfgeuJGhUK8?si=4RrvgVrZZzEM2o7D

(Launch of PSLV-C57)
https://www.youtube.com/live/_IcgGYZTXQw?si=6YsYvoxw0cdVXswI

Answer : Pre-activity - 1. B 2.B, Self Assessment Trivia- 1.C 2.B 3.B 4.A

05 Human Spaceflight

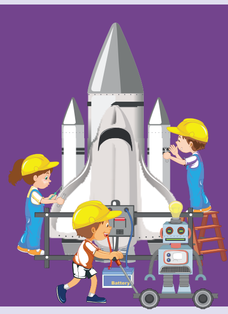
The Ultimate Space Experience

5.1 Space Discoveries Video

To understand how experiments conducted in space lead to discoveries and technologies that benefit life on Earth.

Objective

a. To learn why scientific experiments are conducted in space.
b. To understand the concept of microgravity.
c. To explore discoveries made in space research.
d. To relate space research to everyday applications on Earth.
e. To develop awareness of the importance of human space missions.



Scientific Foundation

Why Send Humans to Space? The Ultimate Science Lab

1. Space: A Laboratory Without a Floor

On Earth, everything we do is ruled by an invisible force: Gravity. It's the reason a ball falls down and why bubbles rise in boiling water. Gravity acts like a "curtain" that hides how science truly works. However, in the International Space Station (ISS), everything is in a state of constant free-fall. This creates Microgravity (near-zero gravity). In this environment, the "curtain" of gravity is pulled back, allowing us to see how nature behaves in its purest form.

2. The 3D Power of Biology

One of the biggest breakthroughs in space is studying human cells.

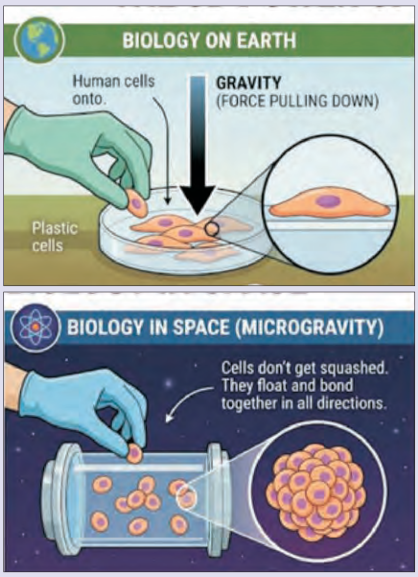
- On Earth: Gravity squashes cells flat against lab dishes, making them grow like thin pancakes. But our bodies aren't flat! Our hearts and lungs are 3D.
- In Space: Because there is no gravity to squash them, cells float and bond in all directions. They grow into 3D models that look and act exactly like the organs inside your body.

Why does this matter? Scientists use these 3D space-grown cells to test new cancer drugs. It's much safer to test a drug on a realistic 3D model in space before giving it to a patient on Earth.

3. Growing "Perfect Crystals"

- Crystals are the building blocks of everything, from the microchips in your phone to life-saving medicines.
- The Problem on Earth: Gravity causes fluids to swirl around a growing crystal, making it jagged and "messy."
- The Space Solution: In the stillness of microgravity, crystals grow slowly and become perfectly shaped.

By studying these "Perfect Crystals," engineers can design super-fast computers and medicines that are much more effective because the body can absorb their pure structure more easily.



4. A "Time Machine" for Human Health

Did you know that space acts like a biological time machine? When astronauts live in weightlessness: Their bones lose strength. Their muscles become smaller.In just six months, an astronaut's bones can age as much as a 60-year-old person on Earth! By studying this "fast-forward aging," researchers have developed better treatments for Osteoporosis (a disease that makes bones weak). The techniques used to keep astronauts fit are now helping millions of grandparents on Earth stay strong.

5. The Secrets of Fire and Water

Even simple things like fire and water act differently in space:

- Spherical Flames: On Earth, a flame is pointed because hot air rises. In space, it burns as a beautiful blue sphere. This helps us learn how to burn fuel better, leading to car engines that cause less pollution.
- Space Water: Because water is heavy to carry to space, the ISS uses advanced recycling. It turns sweat and waste liquid back into pure drinking water! This "Space RO" technology is now providing clean water to remote villages and disaster zones on Earth.

6. Why Humans and Not Just Robots?

You might ask, *"Why not just send a robot?"* While robots are good at taking photos, they cannot innovate. If an experiment shows something strange or unexpected, a robot might ignore it. A human astronaut, however, can notice the mystery immediately, change the experiment, and find a solution. Humans provide the eyes, ears, and brains that turn space observations into real-world solutions.

Real-World Connection

Space agencies conducts microgravity and life science experiments during space missions.

NASA performs research aboard the International Space Station (ISS), leading to advances in medicine, materials science, and environmental technology.

Many everyday technologies have roots in space research.

Lets start with the activity

Materials Required

1) Projector or screen
2) Educational videos on space experiments
3) Notebook and pen
4) Chart paper for discussion

Procedure

Step 1: Introduction
- Explain the microgravity environment.

Step 2: Video Observation
- Show selected space experiment videos.

Step 3: Discussion
- Discuss the differences between Earth and space conditions.

Step 4: Group Activity
- Assign each group one experiment.
- Ask them to explain its Earth application

Observations

Students should observe:

- Floating objects in microgravity.
- Astronauts conducting experiments.
- Differences in flame shape.
- Special laboratory setup in space.

Analysis and Conclusion

The activity demonstrates that microgravity creates a unique environment for scientific study that is impossible to replicate on Earth, leading directly to the development of new technologies. Many everyday innovations - from advanced water filters to specialized medical tools - actually originate from the rigorous demands of space missions. Human space exploration contributes significantly to our global scientific knowledge and drives technological advancement on Earth. By pushing the boundaries of what is possible in orbit, researchers develop solutions that eventually improve the quality of life and industry for everyone.

Did You Know?

Memory foam was originally developed from space research.

Where Else Do We See This Science?

- Memory foam mattresses were originally developed to cushion astronauts during rocket launches
- RO water purifiers used in Indian homes evolved from water recycling technology built for the ISS
- Cancer drug testing in space produces more accurate 3D cell models than any Earth-based lab can
- Scratch-resistant eyeglass lenses use a coating technology first developed for space helmet visors

Additional Links

(Microgravity)
https://youtu.be/GSLwvtF4Zo0?si=6avXGBeigPYFlh6p

(NASA - ISS Expiriment)
https://youtu.be/vKs1mXcA_A4?si=9nKXz1xclT4jIQKy

(Astronaut Training)
https://youtu.be/WvT3hMVrSzs?si=QJWDbZi77ovnMTK0

(Benefits stemming from space exploration)
https://www.nasa.gov/wp-content/uploads/2015/01/benefits-stemming-from-space-exploration-2013-tagged.pdf?emrc=ca90d1

(Top 5 Space Experiments)
https://youtu.be/IvdohUPWg-0?si=Sg53pa9U9qkwN2IS

05 Human Spaceflight

The Ultimate Space Experience

5.2 Water Recycling Demonstration

To understand how astronauts recycle water and manage oxygen (O_2) and carbon dioxide (CO_2) inside a spacecraft.

Objective

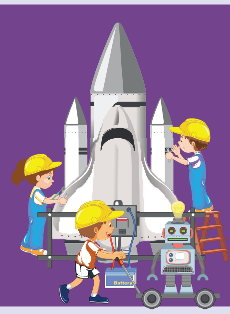
a. To understand the importance of life support systems in space.

b. To learn how water is recycled in spacecraft.

c. To understand oxygen supply and carbon dioxide removal.

d. To relate classroom models to real space missions.

e. To develop awareness about resource conservation.



Scientific Foundation

1. Introduction

Water is one of the most important resources for life, but in space it is extremely limited. On the ISS, carrying large amounts of water from Earth is very expensive and not practical for long missions. Because of this, astronauts cannot afford to waste water. Instead, they use a highly advanced system that allows them to recycle and reuse almost every drop of water. This system ensures that astronauts always have enough clean water for drinking, cooking, and other daily activities, even while living hundreds of kilometers above Earth.

2. Source of Water

On the ISS, water does not come from a natural source like rivers or lakes. Instead, it is collected from different sources inside the spacecraft itself. These include astronauts' urine, sweat from their bodies, and moisture released when they breathe. Even the air inside the station contains tiny water droplets, which are captured using special machines. All of this used or "waste" water is carefully collected so that it can be cleaned and reused again.

3. Water Recovery System (WRS)

To manage and recycle water, the ISS uses a special system called the Water Recovery System (WRS). This system is part of a larger system known as the Environmental Control and Life Support System. The WRS is responsible for collecting used water, processing it, and turning it back into safe, clean water. It works continuously to make sure astronauts always have a steady supply of water without depending too much on Earth.

4. Step-by-Step Process

(a) Collection

The first step is collecting all the used water from different sources such as urine, sweat, and moisture in the air. Special devices are used to pull water from the air and gather it into the system.

(b) Urine Processing

The collected urine is sent to a special machine where it is heated and processed. This process separates water from the waste materials. It is similar to distillation, where liquid is heated to produce vapor and then cooled to collect clean water.

(c) Filtration and Cleaning

After that, the water goes through multiple filters. These filters remove tiny particles, harmful chemicals, and any impurities present in the water. This step ensures that the water becomes much cleaner.

(d) Final Purification

In the final stage, a process called catalytic oxidation is used. This process removes any remaining harmful substances and kills bacteria. After this step, the water becomes completely safe for human use.

5. Uses of Recycled Water

The backpack an astronaut wears is the most important part of the suit. It is called the Primary Life Support Subsystem (PLSS). It is the "brain" and the "lungs" of the spacesuit, performing three vital tasks:The clean water produced by this system is used in many ways on the ISS. Astronauts drink this water, use it to prepare food, and also use it in systems that produce oxygen. This makes the recycled water an essential part of daily life in space.

6. Efficiency

The water recycling system on the ISS is very efficient. It can recover about 90% to 98% of the water that is used. This means that very little water is lost, and the same water can be reused many times.

7. Importance

Water recycling is extremely important for space missions. It allows astronauts to stay in space for long periods without needing constant resupply from Earth. This technology will be very useful for future missions to the Moon and Mars, where carrying water will be even more difficult. It also teaches us an important lesson for life on Earth-that we should save water and reuse it whenever possible to protect our environment.

Real-World Connection

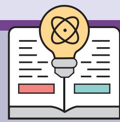
ISRO is developing environmental control and life support systems for future human space missions. NASA uses advanced water recovery and air revitalization systems aboard the International Space Station (ISS). The ISS recycles most of its water to reduce resupply needs.

Lets start with the activity

Materials Required

1) Transparent bottle or container
2) Dirty water sample (soil mixed water)
3) Cotton
4) Sand
5) Gravel
6) Activated charcoal (optional)
7) Chart showing the oxygen–carbon dioxide cycle

Working Principle



This activity demonstrates basic water filtration and gas cycle concepts.

Water Filtration Model

- Layer cotton, sand, and gravel inside the bottle.
- Pour dirty water through the layers.
- Observe the filtered water collected below.

Oxygen–Carbon Dioxide Cycle Discussion

- Humans inhale O_2 and exhale Co_2.
- Plants absorb CO_2 and release O_2 (photosynthesis).
- Spacecraft simulate this balance artificially using technology.

(Water recycling on ISS)
https://www.youtube.com/watch?v=jIHkWpKUm28

Procedure

1

Step 1: Prepare the filter
- Cut the bottle in half.
- Invert the top portion.
- Add cotton, sand, and gravel layers.

Step 2: Filter Water
- Pour dirty water slowly.
- Observe clarity improvement.

2

3

Step 3: Discuss Air Cycle

- Use a chart to explain O_2 and CO_2 exchange.

Step 4: Compare with Space Systems

- Explain how spacecraft use advanced filters and chemical systems.

4

Note: This model demonstrates mechanical filtration only. The ISS uses much more advanced systems including reverse osmosis, chemical treatment, and biological monitoring to produce drinking-quality water from wastewater

Observations

Students should observe:

- Improved clarity of filtered water.
- Layers trapping dirt particles.
- Importance of multiple filtration layers.
- Role of balanced oxygen supply.

Analysis and Conclusion

The activity demonstrates that filtration effectively removes impurities step by step, which is a vital process in closed environments that require advanced recycling systems. Since oxygen must be replenished continuously and carbon dioxide removal is essential for safety, these life support systems are the only way to keep astronauts alive in the vacuum of space. Space missions rely on highly efficient life support systems that recycle both air and water to sustain human life over long periods. These same conservation methods can be applied to our lives on Earth, helping to improve global sustainability and protect our own natural resources.

Did You Know?

The ISS recycles about 90% of its water.

Where Else Do We See This Science?

- Household water filters use sand, gravel, and charcoal layers-exactly the same method used here
- Sewage treatment plants filter and purify wastewater before safely returning it to rivers
- Aquarium filters recycle water continuously to keep fish alive in a sealed, closed environment
- Rainwater harvesting systems in dry regions collect and filter water for reuse, inspired by resource conservation

Precautions & Safety

- ⚠ Do not drink filtered water from the experiment.
- ⚠ Handle materials hygienically.
- ⚠ Dispose of dirty water safely. Avoid spilling water on the floor.
- ⚠ Teacher supervision recommended.

Additional Links

(Water Recycling on ISS)
https://youtu.be/BCjH3k5gODI?si=ilg8KBo-WpkNG0vB

(Recycling in space)
https://youtu.be/6fORgpqSPnY?si=VhIfDgdX6X4J3S2M

(ISS water recycling systems)
https://youtu.be/AzZxg-hCyZs?si=aOwXz_4it6xPrOpg

05 Human Spaceflight

The Ultimate Space Experience

5.3 Underwater Training Videos

To understand how astronauts train underwater to simulate space conditions and prepare for spacewalks.

Objective

a. To understand why underwater environments are used for astronaut training.

b. To learn about microgravity simulation techniques.

c. To observe astronaut training methods.

d. To relate underwater practice to real space missions.

e. To appreciate the preparation required before human spaceflight.

Scientific Foundation

The "Space Body": How Humans Adapt to Zero-G

Your body is a masterpiece designed specifically for Earth. From the way your heart pumps blood to the way your bones support your weight, every part of you is built to fight against **Gravity.**

The moment an astronaut enters space, the "rules" change. The body realizes that the constant downward pull is gone, and it begins to remodel itself in strange and fascinating ways.

Fluid Shift: "Puffy Faces" and "Bird Legs"

On Earth, gravity constantly pulls your blood and body fluids toward your feet. Your heart has to work hard to pump that blood back up to your brain.

In space, that downward pull is gone. The fluids spread out evenly, moving toward the upper body and head. This causes two visible changes:

- **Puffy Face:** Astronauts' faces look swollen, and they often feel like they have a "permanent cold" or a stuffy nose because of the fluid buildup in their head.
- **Bird Legs:** Because the fluid is no longer pooling in the lower part of the body, their legs become very thin.

The Bone and Muscle "Disappearing Act"

The human body is very efficient-it follows the rule: **"Use it or lose it." * Bone Loss**: On Earth, your bones stay strong by supporting your weight. In space, they do zero work. As a result, astronauts can lose up to **1% of their bone** massevery single month!

- **Muscle Wasting:** Without the resistance of gravity, muscles begin to shrink and weaken.

The Solution: To stay fit, astronauts must exercise for about 2 hours every day. They use special treadmills and weight-lifting machines that use vacuum pressure or heavy rubber bands to create the "weight" that gravity usually provides.

Space Motion Sickness: The Confused Brain

Inside your inner ear, you have tiny sensors (the Vestibular System) that act like a “level," telling your brain which way is "up" and which way is "down."

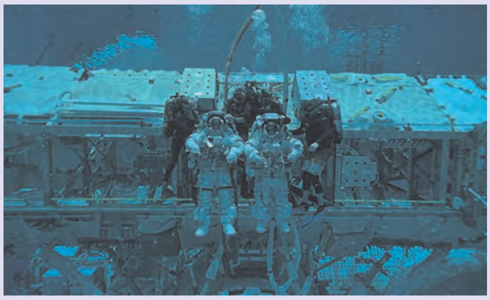
In space, there is no "up." This completely confuses the brain. For the first few days, an astronaut might feel dizzy or nauseous—a condition called Space Motion Sickness. Eventually, the brain learns to ignore the inner ear and relies only on what the eyes see.

Neutral Buoyancy: Training for Space Underwater

Since we cannot easily go to space to practice, how do astronauts prepare? They use a clever scientific trick called Neutral Buoyancy.

How it Works:

When an object in water has an upward "push" (buoyancy) that exactly matches the downward pull of gravity, it neither sinks nor floats. It stays suspended in the middle. This is the closest feeling to "floating" in space that we have on Earth.



- **The NBL Tank:** Astronauts train in massive swimming pools like the **Neutral Buoyancy Lab (NBL)**
- **Weighted Suits:** They wear full spacesuits. Divers add small weights or foam floats to the suit until the astronaut is perfectly balanced.
- **The Goal:** This allows them to practice difficult tasks, like repairing a satellite or handling tools, in an environment that simulates **Micrograviity.**

Real-World Connection

ISRO trains astronauts for human space missions using advanced simulation techniques. NASA uses a giant pool called the Neutral Buoyancy Laboratory (NBL) to train astronauts for spacewalks. These training methods ensure astronauts are fully prepared before going to space.

Lets start with the activity

Materials Required

1) Projector or screen
2) Educational underwater astronaut training videos
3) Notebook and pen
4) Chart paper for discussion

Working Principle

The activity is observation and discussion-based.

- Show videos of astronauts training underwater.
- Explain the neutral buoyancy concept.
- Discuss similarities and differences between underwater and space environments.
- Conduct a group discussion on why training is essential.

(Neutral Buoyancy lab in Houston)
https://www.youtube.com/watch?v=6cwIeHpAUE0

Procedure

Step 1: Introduction
- Explain microgravity and the challenges of spacewalks.

Step 2: Video Observation
- Show underwater training footage.

Step 3: Discussion
- Identify tools and suits used.
- Discuss safety measures.

Step 4: Reflection Activity
- Ask students to imagine performing tasks in floating conditions.

Observations

Students should observe:

- Astronauts floating underwater.
- Heavy space suits are used during training.
- Support divers assisting astronauts.
- Slow and careful movements.

Analysis and Conclusion

The activity demonstrates that underwater training effectively simulates floating conditions, allowing for realistic practice that improves coordination and safety. Astronauts must train extensively in these environments before their missions to ensure they can handle the unique physical challenges of working in microgravity.

Simulation training, especially underwater neutral buoyancy training, is essential for preparing astronauts for safe and successful space missions. By mastering their tasks in a controlled environment on Earth, they are better equipped to perform complex maneuvers and maintain safety while in orbit.

Did You Know?

Astronaut training can take several years before going to space.

Where Else Do We See This Science?

- Pilots train in flight simulators for hundreds of hours before flying a real aircraft
- Surgeons practice complex operations on models and simulators before treating real patients
- Navy divers train underwater for demolition and rescue missions before actual sea deployment
- Firefighters rehearse building rescues in controlled environments before real emergencies

Precautions & Safety

- ⚠ Ensure appropriate educational video content.
- ⚠ Maintain classroom discipline during viewing.
- ⚠ Encourage respectful discussion.
- ⚠ Teacher supervision required.

Additional Links

(Spacewalk)
https://youtu.be/Wfoy_OvNDvw?si=Pa_BoQt6upIJLuhK

(Spacewalk)
https://youtu.be/CC-z_aBAv6M?si=7cVGXtRWHfiDN984

(Astronaut Underwater Training)
https://youtu.be/4514z--Zbfk?si=HxpByfuJuEnRzDfo

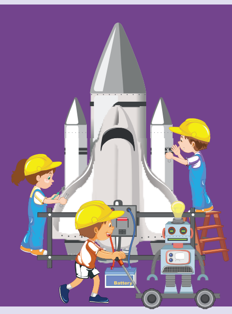
(Training for Spacewalk)
https://youtu.be/zh9jd9L1IRQ?si=r53YGAB2lbH2b1l4

5.4 Daily Routine Board

To understand the daily life of astronauts aboard the International Space Station (ISS) and represent their routine through a visual daily schedule board.

Objective

a. To learn about the daily activities of astronauts in space.
b. To understand how microgravity affects daily routines.
c. To explore time management in space missions.
d. To relate astronaut routines to life support systems and experiments.
e. To develop creative and presentation skills.



Scientific Foundation

Scientific Foundation

Astronauts living aboard the International Space Station (ISS) orbit Earth approximately every 90 minutes. This means they experience about 16 sunrises and sunsets each day.

Despite this, astronauts follow a structured schedule based on coordinated Earth time (usually UTC). A strict routine is important because:Space missions require precise time management.

Experiments must be conducted at specific intervals. Physical exercise is necessary to prevent muscle and bone loss in microgravity.

Effects of Microgravity on Daily Life

In microgravity, objects float freely, so astronauts must adapt to a unique lifestyle. They strap themselves while sleeping, eat specially packaged food, and follow a strict exercise routine to stay healthy.

Their daily routine includes conducting scientific experiments, performing maintenance tasks, exercising for about two hours, and communicating regularly with Mission Control. They also follow fixed schedules for meals and sleep. This structured lifestyle helps ensure safety, productivity, and overall physical well-being.

Real-World Connection

The ISS is a joint project involving space agencies such as NASA and international partners. ISRO is preparing astronauts for structured daily routines in future human space missions. Astronaut time management is critical for mission success.

Lets start with the activity

Materials Required

1) Chart paper
2) Markers and sketch pens
3) Pencil and ruler
4) Reference material (ISS daily routine examples)
5) Stickers or printed images (optional)

Working Principle

This activity demonstrates structured time planning in space.

- Research the typical ISS daily routine.
- Divide the day into time blocks.
- Assign activities such as exercise, research, meals, communication, and sleep.
- Represent routine visually using a chart or timetable.

(A Day in the Life of an Astronaut in Space)
https://www.youtube.com/watch?v=hHyNGnmNg8A

Procedure

1 **Step 1: Introduction**
- Discuss an astronaut's daily life.

2 **Step 2: Planning**
- Divide the chart into a 24-hour timeline.

3 **Step 3: Activity Assignment**
- Add exercise, experiment time, meals, communication, and sleep.

4 **Step 4: Illustration**
- Add drawings of astronauts performing activities.

5 **Step 5: Presentation**
- Explain why each activity is important.

6 **Step 6: Draw two columns:** Astronaut Day and Your Day. Compare when each involves exercise, meals, work/study, and sleep

Observations

Students should observe:
- Importance of exercise in space.
- Differences between Earth routine and space routine.
- Strict scheduling of experiments.
- Limited leisure time in space.

Analysis and Conclusion

The activity demonstrates that a structured routine is necessary to ensure mission efficiency, especially since the environment of microgravity significantly affects even the simplest daily habits. Prioritizing both physical and mental health is a core part of life in orbit, as keeping the crew in peak condition is vital for the safety of the entire spacecraft. Astronauts follow a disciplined daily schedule to maintain their health and ensure the success of scientific missions aboard the International Space Station (ISS). This rigorous time management allows them to balance complex research with the necessary exercise and rest required to live and work in space for months at a time.

Did You Know?

The ISS travels around Earth at about 28,000 km/h.

Where Else Do We See This Science?

- Athletes follow strict daily training, nutrition, and rest schedules to perform at their peak
- Hospital patients follow fixed routines for medicine, therapy, and rest to recover faster
- Submarine crews follow tight daily schedules for watch duty, meals, and sleep in confined spaces
- Antarctic research station scientists follow structured daily routines to stay healthy in isolation

Additional Links

(Space Potty)
https://youtu.be/5WSlGRBTFNI?si=RpaaPatcObGm5SYj

(What Happens When You Wring It?)
https://youtu.be/lMtXfwk7PXg?si=6tt3ZcCvlqPBjtlj

(ISS Tour)
https://youtu.be/XkM_04Ch76E?si=fUnjnGd8_F8BdutT

(Astronauts explain food prep)
https://youtu.be/onm7P_iFueE?si=tYwRuEulpe67V2Dy

05 Human Spaceflight

The Ultimate Space Experience

5.5 Space Glove Box Challenge

To simulate the challenges astronauts face while working in bulky space suits by performing tasks wearing thick gloves inside a confined box.

Objective

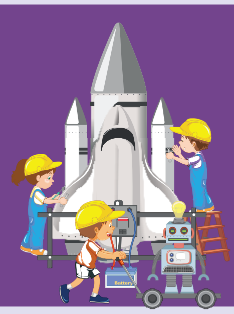
a. To understand why astronauts wear pressurized gloves.

b. To experience reduced hand flexibility (dexterity).

c. To observe how fine motor tasks become difficult in space suits.

d. To relate the activity to astronaut training and spacewalk challenges.

e. To develop patience, coordination, and problem-solving skills.

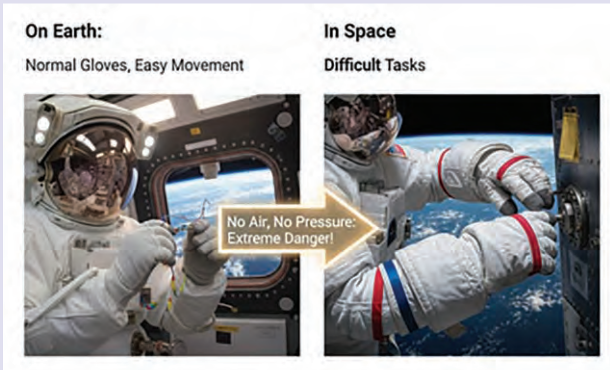


Scientific Foundation

Extra-Vehicular Activity (EVA): Working in the Void

The Survival Challenge: Why Normal Gloves Fail

In the vacuum of space, there is no air and no atmospheric pressure. Our bodies are designed to function under the constant pressure of Earth's atmosphere. Without this pressure, our internal fluids would not behave normally, making survival impossible. To stay alive during a spacewalk, astronauts must wear **Pressurized Space Suits**. The gloves of these suits are the most complex part because they must be:



- **Pressurized:** To keep the astronaut's hands functioning like they do on Earth.
- **Multi-Layered:** To provide insulation against extreme temperatures (from -120°C in the shade to 120°C in sunlight).
- **Armored:** To protect against Micrometeoroids (tiny space rocks traveling at high speeds).

What is Dexterity?

Dexterity is the ability to move your hands and fingers with precision and control. On Earth, we take our dexterity for granted. We easily tie our shoelaces, pick up a tiny needle, turn a small screw with a screwdriver.

The Trade-Off: When a glove is pressurized, it becomes stiff-much like a fully inflated balloon. Trying to bend your fingers in a space suit glove feels like squeezing a hard rubber ball. This makes even simple movements very tiring and difficult.

Why Dexterity Matters During an EVA

An **Extra-Vehicular Activity (EVA),** or "spacewalk," is not just for floating around; it is hard work. Astronauts must perform delicate repairs on the International Space Station (ISS).

The Challenges of Low Dexterity:

- **Connecting Cables:** Aligning tiny pins in electrical connectors is extremely difficult with thick fingers.
- **Handling Tools:** There is a high risk of dropping tools into the void of space, where they can never be recovered.
- **Physical Fatigue:** Because the gloves resist every movement, an astronaut's hand muscles get exhausted quickly. A 6-hour spacewalk can feel like a 20-hour workout for the hands.

Engineering for the Future

Engineers are constantly working to improve glove design. They add mechanical joints and use flexible materials at the knuckles to help astronauts move more naturally. This is a perfect example of Engineering Design: balancing the need for heavy protection with the need for high usability.

Real-World Connection

NASA designs advanced space suits that allow astronauts to work safely during spacewalks.

ISRO is developing space suits for future human spaceflight missions. Astronauts train for years to perform simple tasks while wearing pressurized gloves.

Lets start with the activity

Materials Required

1) Thick winter gloves or padded gloves
2) Cardboard box (with hand holes cut out)
3) Small objects (nuts and bolts, beads, coins)
4) Screwdriver and screws (safe size)
5) Stopwatch

Working Principle

Wearing thick gloves reduces finger flexibility and tactile sensitivity. Students attempt small tasks inside a box while wearing gloves to simulate restricted movement and limited visibility.

Procedure

1

Step 1: Prepare Glove Box
- Cut two hand holes approx 14-15cm diameter in a cardboard box.

2

Step 2: Place Objects Inside
- Place small items such as bolts, beads, or coins.

3

Step 3: Wear Gloves
- Students wear thick gloves.

4

Step 4: Perform Tasks

Attempt tasks such as:
- Picking up small objects
- Screwing a bolt
- Sorting items

5

Step 5: Time the Activity
- Record how long it takes.

6

Step 6: Compare
- Repeat without gloves and compare results.

Observations

Students should observe:

- Difficulty in gripping small objects.
- Reduced speed while performing tasks.
- Increased effort required.
- More mistakes when wearing gloves.

Analysis and Conclusion

The activity demonstrates that thick gloves significantly reduce dexterity, making fine motor tasks both slower and much harder to perform. Because the protection provided by space suits often comes at the cost of flexibility, extensive astronaut training is essential to learn how to adapt to these physical limitations. Space suit gloves are designed to protect astronauts from the harsh environment of space, but they also limit critical hand movement. Engineers must work to carefully balance safety and functionality, ensuring that gloves provide the necessary protection without preventing astronauts from completing their technical mission tasks.

Did You Know?

Spacewalk gloves are custom-made and extremely complex pieces of a spacesuit.

Where Else Do We See This Science?

- Nuclear plant workers handle radioactive materials using thick gloves inside sealed protective boxes
- Beekeepers wear thick protective gloves while handling hive frames, reducing finger movement greatly
- Bomb disposal technicians use heavy protective gloves, requiring extensive practice for precise control
- Welders wear heat-resistant gloves that limit finger movement, demanding skill built through regular training

Precautions & Safety

⚠ Use safe, blunt tools only.

⚠ Supervise use of screwdrivers.

⚠ Avoid sharp objects.

05 Human Spaceflight

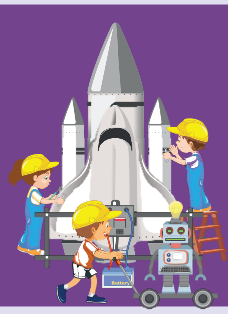
The Ultimate Space Experience

5.6 Human Spaceflight-Animation Movie

To understand the journey of human space exploration through animated educational videos and reflect on its scientific and technological importance.

Objective

a. To learn the history of human space exploration.
b. To understand major milestones in space travel.
c. To explore challenges faced by astronauts.
d. To inspire interest in STEM careers.
e. To develop observation and reflection skills.



Scientific Foundation

Have you ever imagined what it feels like to travel beyond the sky and see Earth from space? Human spaceflight is the science of sending people into space and bringing them back safely. But this is not as simple as riding a vehicle. Space is a very dangerous place where there is no air to breathe, temperatures can be extremely hot or cold, and harmful radiation is present. To survive in such conditions, astronauts travel inside a specially designed spacecraft that works like a small home. It provides oxygen to breathe, water to drink, food to eat, and protection from the harsh space environment. A human space mission is a complete journey. First, a powerful rocket lifts the spacecraft by overcoming Earth's gravity. Then, astronauts live and work in space where there is almost no gravity. Finally, the spacecraft must return safely to Earth by facing extreme heat during re-entry. Human spaceflight is not just about going to space it is about science, technology, and human courage working together to explore the unknown.

India's human spaceflight mission

Have you ever imagined what it feels like to travel beyond the sky and see Earth from space? Human spaceflight is the science of sending people into space and bringing them back safely. But this is not as simple as riding a vehicle. Space is a very dangerous place where there is no air to breathe, temperatures can be extremely hot or cold, and harmful radiation is present. To survive in such conditions, astronauts travel inside a specially designed spacecraft that works like a small home. It provides oxygen to breathe, water to drink, food to eat, and protection from the harsh space environment. A human space mission is a complete journey. First, a powerful rocket lifts the spacecraft by overcoming Earth's gravity. Then, astronauts live and work in space where there is almost no gravity. Finally, the spacecraft must return safely to Earth by facing extreme heat during re-entry. Human spaceflight is not just about going to space it is about science, technology, and human courage working together to explore the unknown.

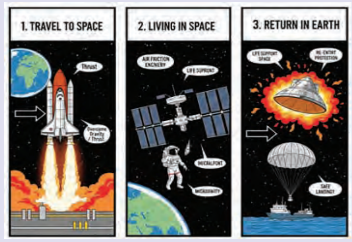
India's human spaceflight mission

Astronaut Group Captain Shubhanshu Shukla, A.C. the first Indian to reach ISS and 2nd Indian to go to space 48 years after the legendary visit of Astronaut Rakesh Sharma. This is a very special moment for our country because India is now preparing to send its own astronauts into space through it's own rocket. His mission is not just about going to space, but also about doing important science experiments in a place where there is almost no gravity. These experiments help scientists learn new things that cannot be studied on Earth. All these learnings of space will be helpful for the upcoming mission of Gaganyaan. Through this mission, India is taking a big step forward in space research and future space exploration.

Experiments Performed in Space

A. **Liquid Behavior in Space:** Liquids float and form spheres in microgravity, helping design water and fuel systems.

B. **Crystal Growth in Space:** Crystals grow more perfectly in space, useful for medicines and electronics.
C. **Human Body in Space:** Microgravity weakens muscles and bones, helping study astronaut health.
D. **Plant Growth in Space:** Plants grow based on light instead of gravity, important for space farming.
E. **Fire in Space:** Fire burns in a spherical shape, helping improve spacecraft safety.
F. **Materials in Space:** Materials behave differently in vacuum and radiation, helping build stronger spacecraft.



In this activity we would be going in more depth of Astronaut Group Captain Shubhanshu Shukla's exciting journey to ISS through this movie and about the experiments performed in space

Real-World Connection

ISRO is preparing for human spaceflight missions under its Gaganyaan program. NASA has conducted historic missions including Moon landings and International Space Station operations. Human space exploration continues to expand scientific knowledge and technological capability.

Lets start with the activity

Materials Required

1) Projector or display screen
2) Selected animated educational movie
3) Speakers
4) Notebook and pen
5) Reflection worksheet

Procedure

1. **Step 1: Introduction**
   - Briefly introduce topic of human space exploration.

2. **Step 2: Watch Video**
   https://www.youtube.com/playlist?list=PLe8QoqrwXb4QzLNncivND7h7i2Y5rKLae

3. **Step 3: Guided Discussion**
   - Ask students to identify scientific principles observed.

4. **Step 4: Reflection Activity**
   - Ask students to write 5 things they learned.

Observations

Students should observe:
- Rocket launch sequences.
- Astronaut activities in space.
- Microgravity effects.
- Re-entry and landing process.

Movie Summary

This film follows the inspiring journey of Group Captain Shubhanshu Shukla, AC India's astronaut who flew to the International Space Station on Axiom Space Mission Ax-4. From Indian Air Force test pilot to months of grueling astronaut training across the world, the film captures milestone of his extraordinary path to space. students will witness the physical, mental, and technical challenges that every astronaut must overcome before they can leave Earth's atmosphere. Onboard the ISS, Gp. Capt. Shubhanshu Shukla, AC conducted scientific experiments and represented India among the world's finest space explorers. This film is a tribute to India's growing ambitions in human spaceflight and a call to the next generation to dream boldly, work relentlessly, and reach for the stars.

Did You Know?

The ISS has been continuously occupied by humans since 2000.

MAPPING OF LEVEL 2 SPACE ACTIVITIES TO NCERT CHAPTERS

Module	Number	Chapter/Topic	Book (NCERT)
1. Launch Module	1.1	Build Arduino Based Launch Checklist System	Class 9, Physics, Chapter 8,Chapter 9, Force and laws of motion,Gravitation
	1.2	Sugar Rocket with Thrust Measurement	Class 9, Physics, Chapter 9, Gravitation
	1.3	Build Pressure Sensors and Calculations	Class 9, Physics, Chapter 9, Gravitation
	1.4	Two-Stage Water Rocket with Mechanical Separation	Class 9, Physics, Chapter 7, Motion, FORCE AND LAWS OF MOTION
	1.5	Projectile Motion With and Reduced Drag Demonstration	Class 9, Physics, Chapter 7, Motion, FORCE AND LAWS OF MOTION
	1.6	Orbital Velocity and Escape Mechanics	Class 11, Physics, Chapter 7, Motion, FORCE AND LAWS OF MOTION
2. On Orbit Module	2.1	Calculate Orbital Period – Determining Orbit Time from Altitude	Class 11, Physics, Chapter 7, Gravitation
	2.2	Solar Panel Efficiencyand Sun-Tracking Design	Class 12, Physics, Chapter 14, Semiconductor Electronics: Materials, Devices and Simple Circuits,
	2.3	Stefan–Boltzmann Law and MLI Blanket Design	Class 11, Physics, Chapter 11, Thermal Properties of Matter
	2.4	Controlling Orientation With Reaction Wheel	Class 11, Physics, Chapter 6, System of Particles and Rotational Motion
	2.5	Sensor Interface and Telemetry Monitoring	Class 12, Physics, Chapter 14, Semiconductor Electronics: Materials, Devices and Simple Circuits
	2.6	Obstacle Detection and Terrain Navigation Rover	Class 12, Science, Chapter 9, Ray Optics and Optical Instruments
3. Recovery / Orbital Maneuvers	3.1	Velocity Change Calculation and Trajectory Analysis	Class 9, Physics, Chapter 11, Sound
	3.2	Safe Re-entry Corridor and Angle Analysis	Class 9, Physics, Chapter 7, Motion
	3.3	Heat Shield Mass Loss and Thermal Protection Comparison	Class 9, Physics, Chapter 8, Force and Law of Motion
	3.4	Multi-Stage Parachutes and Deployment System	Class 9, Physics, Chapter 7, Motion
	3.5	Precision Landing Challenge Using Fins	Class 9, Physics, Chapter 10, Work and Energy
	3.6	Capsule Design – 3D Modeling and Virtual Walkthrough	Class 10, Physics, Chapter 9, Light Reflection and Refraction
4. Ground Segment & Mission Operations	4.1	Building Communication System using Arduino Transceiver	Class 10, Physics, Chapter11, Electricity
	4.3	Decoding SSTV Images from the ISS	Class 12, Physics, Chapter8, Electromagnetic waves
	4.4	Drone-Based 3D School Mapping and Analysis	Class 10, Mathematics, Chapter 8, Introduction to trignometry
	4.5	Mission Command & Control Simulation	Class 10, Science, Chapter 11, Electricity

MAPPING OF LEVEL 2 SPACE ACTIVITIES TO NCERT CHAPTERS

Module	Number	Chapter/Topic	Book (NCERT)
5. Human Space & Microgravity	5.1	Microgravity Research Space-Based Phenomena	Class 10, Biology, Chapter 5, Life processes
	5.2	Spacesuit Dexterity Simulation and Thermal Insulation Design	Class 11, Physics, CHAPTER 12, THERMODYNAMICS
	5.3	Centrifuge Training, G-Forces and Human Physiology	Class 11, Physics, CHAPTER 4, MOTION IN PLANE
	5.4	Building and Integrating ISS Modules	Class 11, Physics, CHAPTER 8, GRAVITATION
	5.5	Design and Engineering Secure Systems for Spacewalks	Class 11, Physics, CHAPTER 5, LAWS OF MOTION
	5.6	Real Stories – Apollo 13 & ISS Emergencies:	Class 11, Physics, CHAPTER 8, GRAVITATION

ADDITIONAL RESOURCES

Space Modules

Explore other levels of the 3-tier Space Module here

https://aim.gov.in/space-module.php

AI for Space Module

Developed by NITI Aayog in collaboration with Intel India, this comprehensive STEM program integrates AI-driven decision systems with mission-based simulations. Experience hands-on scientific experimentation inspired by the real-world aerospace operations of ISRO and NASA.

https://ai-for-space.digitalreadiness.org/

Activity Playlist

Watch these concepts come to life! Tune into our curated activity playlist featuring top creators. Follow along with step-by-step demonstrations, expert tips, and creative ways to explore the wonders of space.

https://www.youtube.com/playlist?list=PLe8QoqrwXb4QzLNncivND7h7i2Y5rKLae

Learn more about other ATL Learning Resources

https://aim.gov.in/atl-curriculum.php

NITI Aayog

ATAL INNOVATION MISSION

IDYM Foundation

Space