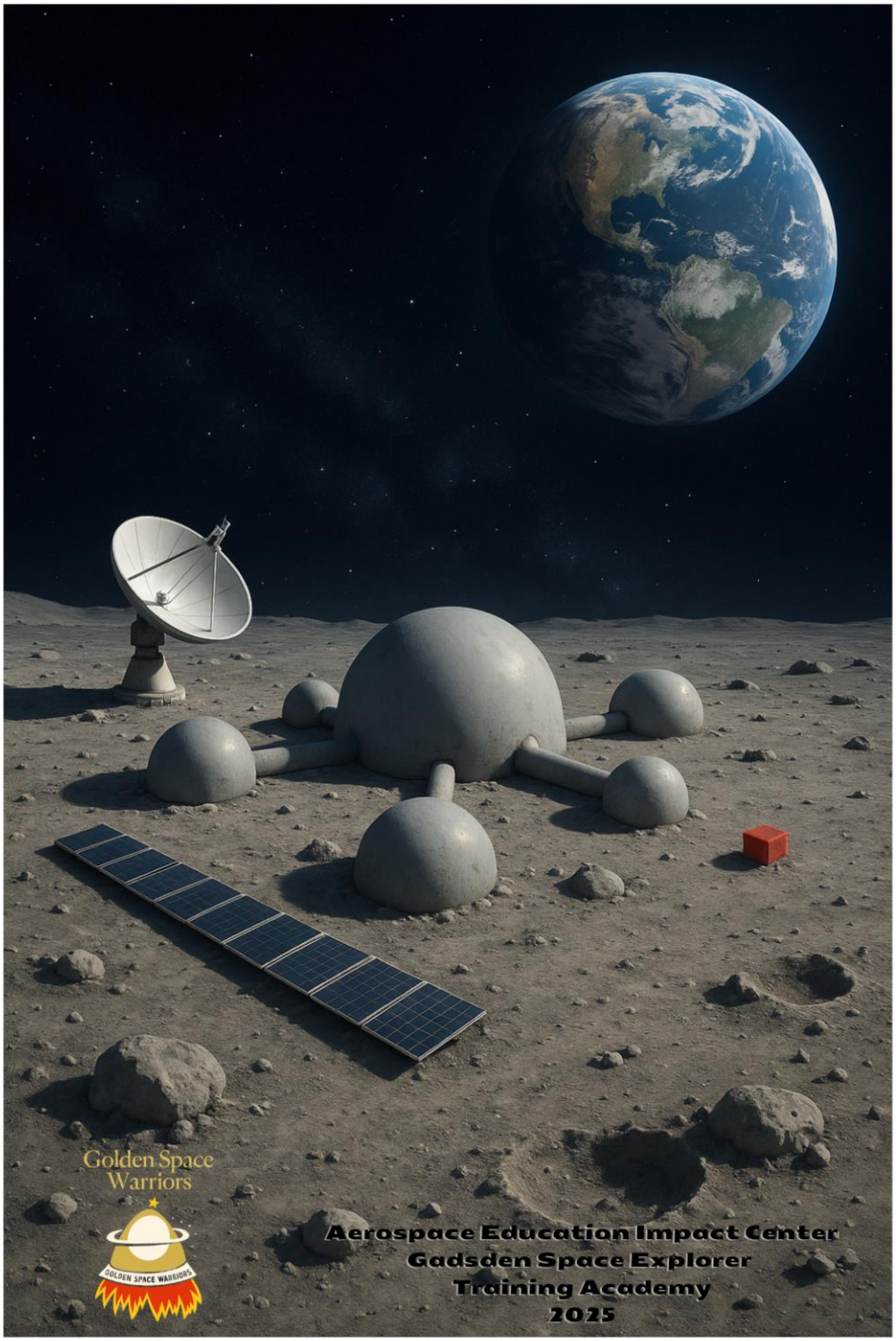
Aerospace Education Impact Center

# LUNAR BASE DESIGN CHALLENGE

## (Middle school version)


Golden Space Warriors
GOLDEN SPACE WARRIORS
Aerospace Education Impact Center
Gadsden Space Explorer
Training Academy
2025

# Aerospace Education Impact Center

**AEIC Mission Statement**

*To create a multi-university center of excellence that supports the NASA continuum for multiple audiences and NextGen STEM activities.*

**AEIC Vision Statement**

*AEIC is a center that increases STEM education participation and student engagement to ensure a continuing and enduring flow of well-prepared candidates for aerospace enterprises and companies. AEIC captures educator and student interest in STEM fields and channels it through programs and activities for all students, with special emphasis on schools and communities with challenges to STEM attainment.*

The ***Aerospace Education Impact Center (AEIC)*** at Florida A&M University (FAMU) is the hub of a 'hub-and-spoke structure. This structure's focus is an envisioned national network of universities (including HBCUs and MSIs), schools, industry partners and informal education institutions. The AEIC will:

- Conduct research and develop and deploy space education programs expressly designed to support and develop underserved women and minority students in the K-20 learning space.
- Be designed as a focal point for programs that support NASA's ***Inspire – Engage – Educate - Employ*** continuum.
- Reside in the FAMU STEM Center of Excellence's Total Learning Research Initiative. Its resources include education, science, and engineering expertise and a network of aerospace education development experts with deep roots in NASA education activity.

Center staff includes nationally recognized space educators with extensive program design, development, and management experience.

## Program Philosophy and Objectives

The **LUNAR BASE DESIGN CHALLENGE)** uses the intrinsic motivation of space-related activities and the multi-disciplinary nature of aerospace exploration to create a dynamic learning space for middle school students. The educational underpinnings include all three learning domains - cognitive, affective, and psychomotor, a robust set of life and learning skills, literacy skills, interpersonal and intragroup skills, creative and design skills, as well as topics in science, technology, engineering, and mathematics.

The **Objectives** include:

- The ability to work effectively in a team environment
- The awareness and development of health and wellness skills
- The ability to brainstorm and think critically
- The ability to problem-solve
- The awareness of the STEM workforce environment

**Cognitive** activities will include:

- Basic life- support environmental factors and interdependence
- Basic engineering design principles
- Basic understanding of building systems and living requirements
- Ability to research topics and report them back to team members

**Affective** activities will include:

- The development of valuing skills including readiness and active participation
- The development of intrapersonal skills in the team environment
- The development of group dynamics and decision-making skills
- The development of organizational and leadership skills

**Psychomotor** activities will include:

- An awareness of the effects of spaceflight on the human body

**Life and Learning** skill development

- The development of skills in a team setting
  - Brainstorming, Idea data reduction, analysis, types of decision making
  - Giving and receiving feedback (interpersonal and intragroup)
  - Personal and team recognition
- Nutritional awareness
- Team health and monitoring

**Creative and Design** skills

- The opportunity to design team-based technology and engineering projects
- The opportunity to create technical and artistic representations and models

**Literacy and Language Arts**

- The development of research skills
- The ability to report data and information

# Comprehensive STEM Education -TEAMING (CSET)

## Understanding standards in the CSET environment

**CSET is the next generation STEM classroom curricular model. It incorporates a "whole curriculum" approach helping students understand how STEM subjects, which are traditionally stove piped, are integrated and multi-disciplinary.**

**A key feature of this pedagogy is that it mirrors the integrated skill sets needed for today's STEM workplace. The seamless inclusion of a workplace modelled team-based approach (TEAMING) reinforces the strength of this School-to Work skills curriculum.**

**Applying standards in this environment requires some adaptation. In the scope and sequence of traditional curricula, standards are often limited to a specific subject in a specific lesson. The CSET environment expands to include multi-disciplinary standards within the same lesson. In addition, CEST overlays national Technology standards in virtually all lessons.**

**TEAMING introduces Interpersonal and Intragroup skills which are a part of virtually every contemporary workplace.**

## CSET Design Outline

| Period | Lesson Name | CSET Content Elements |
|---|---|---|
| 1 | The Challenge and your team | **History**, The Space Race, The Apollo Missions<br>**Astronomy**, The Sun Earth Moon System<br>**Environmental Science**, Earth vs moon life support |
| 2 | Why Build a Base on the Moon? | **Science**<br>**Biology**, How people survive in space, nutrition, air pressure, oxygen, water<br>**Agriculture**, How to grow food in space<br>**Astronomy**, How to study space with large telescopes<br>**Geology,** Mining the moon, rocks and minerals<br>**Engineering),** Construction with little gravity<br>**Social Studies** (<br>Government, how will the base be governed?<br>Law, Earth law or new laws?<br>Ethics, Right and Wrong on a closed base |
| 3 | Structures and Shapes | **Engineerin**g Building structures, habitability, Earth spaces vs lunar spaces<br>**Mathematics**<br>Geometry, Shapes - Cubes. Domes, Tunnels<br>Measurement – Rectangular and circular areas |
| 4 | Life Support Systems | ***Environmental Sciences***<br>Water, Quality, purification, recycling<br>Air, Quality, filtration, Oxygen, CO2<br>Waste Management, recycling and storage<br>**Technology**<br>Power Systems) Solar, batteries, fuel cells, nuclear |
| | | |

| | | |
|---|---|---|
| 5 | Construction on the Moon | **Science** Resource Production and Management, O2, Hydrogen, He3,<br>**Technology** Mining processes<br>**Mathematics** Weights and measures<br>**Engineering**, Structural Dimensioning - amounts of material needed |
| 6 | Designing the base layout | **Art and Design** sketching ideas<br>**Problem Solving**, Finding solutions with constraints<br>**Project Planning**, Roles and responsibilities, collaboration<br>**Mathematic**s Scale, Measurement, coordinates |
| 7 | Building the 3D Model Part 1 | **Project Planning**, Scale, Measurement,<br>**Structured Activity**, Collaboration, procedures, following instructions, interesting instructions, collaboration<br>**Mathematics** scale, measurement, coordinates |
| 8 | Building the 3D Model Part 2 | **Structured Activity**, Following instructions, collaboration<br>**Language Arts** Documentation |
| 9 | Presenting Your Design | **Team Presentations**<br>**Science, Technology and Engineering** Concepts<br>**Language Arts** Explanation, Public Speaking<br>**Final Process Observation**<br>**Team Appreciation** |
| 10 | | |

## Embedded TEAMING skills activities

Forming your team

Picking a Design Team Name
Designing a Mission Patch
Process Observation
Check In and Check Out
Picking Mission Objectives
Picking a Base Name
Organizing the Final Briefing
Celebrating Team Success

## Program Implementation

The Challenge consists of 10 lessons and is designed for use in a variety of settings and flexibility of delivery. The first 5 lessons provide the introduction and skill building for team participation, and the concepts and content required to understand the CSET-STEAM environment for designing the Lunar Base. Lessons 6-8 are the design and model building activities. Lesson 9 is for Team Presentations and TEAMING Learning summary. The 10th lesson is scheduled if needed to complete the program. Lessons also contain optional discussions, videos, and activities at the discretion of the leader/ facilitator. The delivery format can vary.

In-class
The lessons can be delivered during normal subject-appropriate periods or as components of a block schedule. They can be scheduled to be completed in a week, bi-weekly, or once per week for ten weeks.

Extra-curricular
The lessons can be delivered in a club or enrichment format outside of the formal class schedule weekly, or as weekend or inter-semester activities.

Workshops and Camps
The lessons can be delivered on workshops formats spread out over a whole program, in half-day modules, or in an intensive two-day experience.

# TEAMING Classroom Facilitation

Starters:

-Teams should have 5 or 6 members.

If the class size is not divisible by five or six, count off by fives and distribute the remainder to make teams of six.

-A classroom may have 4 to 6 teams.

-Your role will include traditional teaching to the whole class and facilitation and coaching when they work in teams.

-During team sessions, circulate amongst the groups. LISTEN for:

- Their process
- Their progress with the activity
- Any signs of disagreement
- Any inaction or confusion

-If you hear anything that is not on task:

- Ask if they want help
- Ask if there is a problem
- Remind them of the Foundation Five
- Check for understanding of the task

IT IS EASIER TO MONITOR 5 TEAMS THAN 30 INDIVIDUSALS.

# Assessment

- Completion of worksheets with data tables, sketches, and answers
- Participation in a team discussion Session

- Shared Learning Questions at the end of each lesson

- Check in and check out engagement

## Rubric (20 points total)

| Criteria | Excellent (4) | Good (3) | Fair (2) | Needs Improvement (1) |
|---|---|---|---|---|
| Understanding of Content or Principles | Thorough explanation of lesson principles and content | Mostly clear | Some misconceptions | Major misconceptions |
| Data Collection & Accuracy | Complete, accurate, well-organized | Mostly accurate | Missing data | Incomplete |
| Participation | Fully engaged | Mostly engaged | Occasionally distracted | Disengaged |
| Safety | Always followed Foundation 5 rules | 1 reminder needed | 2 reminders needed | Unsafe behavior |
| Reflection | Insightful connections to real-world | General connection | Vague connection | No connection |

# LESSON 1

| Lesson | Title | Topic | Time (Min) |
|---|---|---|---|
| 1 | **The Challenge and your team** | **Introductions and forming your team**<br><br>**The Foundation Five Team Rules**<br><br>**Picking a TEAM NAME**<br><br>**Process Observation**<br><br>**History**, The Space Race, The Apollo Missions<br><br>**Astronomy**, The Sun Earth Moon System<br><br>**Environmental Science**, Earth vs moon life support inquiry | **10**<br><br>**5**<br><br>**15**<br><br>**5**<br><br>**5**<br><br>**5**<br><br>**10** |

## OBJECTIVES

Understand why some activities are better done in teams.

Be able to name the **Foundation Five.**

Understand the Four processes in making a team decision**.**

Understand why America went to the moon.

Be able to name three differences between the Earth and moon.

## STANDARDS

See Program Standards Document

### Welcome and Introductions (TEAMING activity)

Introduction of faculty and students

Each student gives their name and one thing they would like to share about themselves. If the team has members from different grade levels or schools, that should be included in their introduction.

## The Challenge

**Your team will design the first permanent base on the moon. It will have up to 10 astronauts as crew. It will be built mostly from lunar materials and process oxygen and water which are available. It should be as self-sufficient as possible but will be able to be resupplied from Earth.**

## Team Formation

Teams can be assigned by age,

grade,

skill level,

or other grouping.

The ideal number of members to be assigned to a team is 5 or 6. Less than 5 is less than optimal since the strength of the team process is in distributed responsibility, variety of input, and ability to do meaningful work. Dyads and triads are not teams. Greater than 6 members and decision making becomes too difficult.

Assignment of members to teams needs to be random.

Random assignments provide an opportunity for team members to learn how to work with a variety of team members, their styles, preferences, and strengths.

One random assignment procedure is:

Have the participants lined up in order by:

Birth date (month and day)
or

Last name (alphabetical)

Have the participants count off based on the number of teams to be formed. Then people with the same number (the 1s, the 2s, etc.) are members of the same team.

Part of forming a team is establishing ground rules for how team members will treat each other.  The recommended ground rules for a team are called The **Foundation Five**. They are listed below and are covered in more detail in the in-service training materials.

1. *Treat others the way you want to be treated*.
2. *Walk the talk*.
3. *Value another's views and worth*.
4. Be *part of the solution, not part of the problem*.
5. *Hang together, not separately*.

**TEAM DISCUSSION: Have team members discuss what each of the five rules means to them and why they might be important to the team.**

# Choosing a Team Name (Use the TEAM NAME DEVELOPMENT WORKSHEET)

Teams require a set of skills to do things like make decisions, plan, or problem solve. AEIC uses the TLRI TEAMING system which defines the common processes needed for effective student collaboration.

The Choosing a Team Name exercise will teach the team members the decision-making process which they will use throughout the program.

The four skills used in making a team decision are the ability to do:

- Brainstorming (to generate ideas)
- Data reduction (to sort and reduce ideas)
- Analysis (to discuss options)
- Decide (techniques to reach an acceptable solution)

Following this process may seem formal and complex, but they assure several crucial aspects of team building and maintenance: every member of the team participates, a broader range of ideas or options are explored, and the team members are better able to support the decision.

**Brainstorming**

Before Team members can make a team decision, they should make sure they have examined as broad a range of options as possible. One of the easiest and most enjoyable ways to generate a list of ideas is to brainstorm. A successful brainstorm lets people be as creative as possible and does not restrict their ideas in any way. The free-form approach can generate excitement in the group, equalize involvement, and often result in original solutions to problems.

Some helpful rules for conducting brainstorming sessions are:

- Encourage everyone to freewheel; don't hold back any ideas even if they seem silly – the more ideas the better.
- No discussion during brainstorming – that will come later.
- No judgment or criticism of others' ideas – no groans or faces either.
- Encourage hitchhiking – build upon others' ideas
- Write all ideas on the worksheet so that all Team members can easily see them.

Before starting the brainstorming session, it may be helpful to first review the topic and/or question to be answered and give everyone a moment to think in silence. Someone who is a good facilitator should lead the group and write down the answers (or a separate recorder appointed). The facilitator should invite everyone to call out their ideas and have them recorded.

**Data Reduction**

The next step is to look at the ideas and try to reduce them. All ideas should be considered to show that all ideas and the members proposing them are valued. Try to reduce the number of ideas by combining similar ones and agreeing on ones that follow a theme the team likes.

**Analysis**

The team then discusses the different options and members can explain why they came up with the idea. The team can discuss the different options.

**Decide**

The actual decision should not be a simple vote. This creates a winner or winners and losers which is destructive to effective team formation and maintenance. Other ways of reaching a decision are Rank Order and Consensus.

**Rank Order**

A simple rank order is to ask each member to choose their top three options and rank them 1,2,& 3. Totaling up the votes, the options with the lowest scores would be most preferred by the whole team.

**Consensus Decision-making**

Reaching decisions by consensus can be both good and bad. The bad news is that it can take a long time and requires that every team member either approves or says they can live with the decision. A single no vote keeps the process and discussion going.

The good news is that:

*Once consensus is reached, implementing decisions is much faster.*
*The process builds strong team participation.*
*The process builds team trust.*
*The process improves participant's listening skills.*
*The process reinforces the Foundation Five Ground rules for how members agree to treat one another.*
*The process can help resolve complex issues*

There are three steps that a team follows when making a consensus decision

- The presentation of the issue or topic
- Thorough discussion of the issue or topic
- Making the actual decision

Presentation:
The decision to be made is stated and any relevant information is shared. The group may want to gather more information. Each person should also identify their "interest" in the topic (what the decision would mean to them). No solutions or positions should be put forward in this step.

Discussion:
All ideas for deciding the issue should be on the table along with individual and group interests. All ideas should be equal in the discussion, and all ideas should be explored thoroughly.

Decision:
Actually making the decision involves a "test" for consensus. As with any other type of team decision, a member can either agree or disagree. If there is a disagreement by anyone, more discussion is required. In consensus decision-making, there is another category: can you live with the decision. You may not be in full favor of a decision, but you can agree with reservations. When every team member either agrees or can live with a decision consensus is reached, and the team can then move to implement the decision.

**Choosing a TEAM NAME (TEAMING)**

Using the Worksheet, have the team walk through the decision-making process. Again, it may seem complicated at first, but once mastered, it can go very rapidly.

## TEAM NAME DEVELOPMENT WORKSHEET

STUDENT NAME TEAM NAME IDEA

________________________________________________

________________________________________________

_______________________________________________

________________________________________________

________________________________________________

________________________________________________

________________________________________________

ARE ANY OF THE NAMES SIMILAR? COULD THEY BE PUT TOGETHER?

DISCUSSION (ANALYSIS)

HOW TO SELECT (DECIDE)

RANK VOTE____ CONSENSUS_____

ALL AGREE____

LET ONE DO IT____

________________________________________________

OFFICIAL TEAM NAME

## Process Observation (TEAMING)

This analytical tool can be used periodically throughout the TEAMING experience to monitor and improve interactions and observe how well the team is running. It consists of 8 questions which provide a snapshot of the team's interpersonal, intragroup, and leadership dynamics. While relatively quick and simple, it is very powerful.

Team members get an opportunity to observe, monitor, discuss, and improve group activity. Process Observation has been used successfully with teams as young as fourth grade.

Procedure

Normally, one team member is designated as an observer and still participates in the activity. The team adult facilitator may want to be the process observer for the first time with each team. The Observer simply watches for specific behaviors during activity session and takes notes on the Observer form. (See the sample Process Observer Form.) At the end of the activity, the Observer reports his or her observations. Then the whole team talks about what behaviors to encourage, what to discourage, and what deserves further discussion. This information helps the team study and improve how members interact.

Some tips for the Observer are:

Report what you hear and see. Avoid reporting what you "think" is going on in other people's minds.

Report actions, not what caused them.

If there is conflict, ask the adult facilitator for help.

# PROCESS OBSERVER WORKSHEET

HOW WELL DID THE GROUP WORK TOGETHER?

DID EVERYONE TALK?

DID SOME TALK MORE THAN OTHERS?

WAS ANYONE BOSSY?

DID SOMEONE ACT LIKE A LEADER?

DID THE REST OF THE TEAM FOLLOW?

WAS THERE ANY ARGUING?

DID THE TEAM GET FINISHED?

PO-1

## History The Space Race

- Oct 4, 1957: Sputnik 1 - First artificial Earth satellite.
- Nov 3, 1957: Sputnik 2 - First living creature (dog Laika) in orbit.
- Sep 12, 1959: Luna 2 - First spacecraft to impact the Moon.
- Apr 12, 1961: Vostok 1 - Yuri Gagarin, first human in space and Earth orbit.
- Jun 16, 1963: Vostok 6 - Valentina Tereshkova, first woman in space.
- Mar 18, 1965: First spacewalk (Alexei Leonov, Voskhod 2).

United States Milestones:

- Jan 31, 1958: Explorer 1 - First US satellite.
- Oct 1, 1958: NASA established.
- May 5, 1961: Freedom 7 - Alan Shepard, first American in space.
- Feb 20, 1962: Friendship 7 - John Glenn, first American in orbit.

Jul 20, 1969: Apollo 11 - Neil Armstrong & Buzz Aldrin, first humans on the Moon.

VIDEO link The Space Race

https://m.youtube.com/watch?v=xvaEvCNZymo&pp=0gcJCR4Bo7VqN5tD

## The Apollo Missions 1968-1975

| FLIGHT | Mission |
|---|---|
| Apollo 7 | Earth Orbit test flight |
| Apollo 8 | First flight around the moon |
| Apollo 9 | Earth Orbit test of lunar module |
| Apollo 10 | First lunar orbit and lunar module test |
| Apollo 11* | First humans land on the moon |
| Apollo 12* | Second moon landing |
| Apollo 13 | Space emergency and rescue |
| Apollo 14* | Third moon landing |
| Apollo 15* | Fourth moon landing |
| Apollo 16* | Fifth moon landing |
| Apollo 17* | Sixth moon landing |
| Skylab | Space station launch |
| SL-2 | One month mission |
| SL-3 | Twp month mission |
| SL-4 | Three month mission |
| Apollo-Soyuz | United States and Soviet (Russian) Earth Orbit link up |

**VIDEO link - Learning to walk on the moon**

**https://youtu.be/IYQTCAOgrVQ**

**OPTIONAL VIDEO The Space Race**

**https://youtu.be/IYQTCAOgrVQ**

**Astronomy, The Sun Earth Moon System**

**The moon is our nearest neighbor in space. Apollo spacecraft made the trip from Earth to the moon in 3 days. A trip to Mars might take a year.**

**VIDEO Sun – Earth – Moon**

https://www.youtube.com/watch?v=W47Wa7onrIQ

## Space Environment (SCIENCE)

### Imagine you lived 20,000years ago.

**Inquiry 1**: What does planet **Earth** provide to keep humans alive?

Possible answers:

- Gravity
- Air (Oxygen)
- Atmosphere (pressure)
- Water (rain, streams, rivers, lakes, snow, ice, glaciers)
- Food (animals and vegetables)
- Waste disposal
- Shelter (Caves, building materials - wood, stone, Ice, plants, animals)
- Space radiation protection (Cosmic rays, solar rays)

**Inquiry 2**: If you were floating in space or standing on the moon, what would you NOT have?

Possible answers:

- Space - no gravity
- Moon – 16% 1/6 gravity
- No Air
- No Atmosphere
- No water
- No waste disposal (bathroom)
- No shelter
- No radiation protection

# **OPTIONAL** Team-building activity

## Team Mission Patch Design (TEAMING)

Every space mission crew gets to design a mission patch to wear on their flight suits. For this activity, each team will have the opportunity to use the decision making process to design and draw a patch for their team.

Part 1: Provide the teams with a series of mission patch design template options. Have each team pick one member to be the Process Observer. Have the observers gather to receive their instructions and "Observer Worksheet" forms.

Part 2: Ask the team to pick a shape for the patch. The patch can be circular, triangular, rectangular or other regular shape. Generally, patches can have the group name, the names or initials of the members and pictures of a spacecraft, celestial objects (planets, constellations, etc.) and symbols (mathematical, astronomical, school logos, etc.). Use the **MISSION PATCH DESIGN 1 WORKSHEET** to select the shape and theme of the patch.

Part 3: Have the group use the Decision-Making worksheet and process to decide on the graphic elements in the patch:

- **Symbol**
- **Team member names**
- **Image** (rocket, capsule, moon, comet, star constellation)

Samples of actual mission patches should be researched and shared with the teams.

## MISSION PATCH DESIGN 1 WORKSHEET

Brainstorm

STUDENT NAME SHAPE AND THEME

______________________________________________________

______________________________________________________

_____________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

ARE ANY OF THE IDEAS THE SAME? COULD THEY BE PUT TOGETHER?

DISCUSSION (ANALYSIS)

HOW TO SELECT (DECIDE)

RANK VOTE____ CONSENSUS_____
ALL AGREE____
LET ONE DO IT____

______________________________________________________

SHAPE AND THEME

# MISSION PATCH DESIGN 2 WORKSHEET

BRAINSTORM

STUDENT NAME IMAGE and COLORS

_______________________________________________

_______________________________________________

______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

ARE ANY OF THE IDEAS SIMILAR? COULD THEY BE PUT TOGETHER?

DISCUSSION (ANALYSIS)

HOW TO SELECT (DECIDE)

RANK VOTE____ CONSENSUS_____
ALL AGREE____
LET ONE DO IT____

_______________________________________________

IMAGE and COLORS

## Team Mission Patch Production and Presentation (TEAMING)

Team members should identify each member's role in mission patch production. Obviously, some members may have more skill at drawing, but an effort should be made to engage as many people as possible.

Tasks include:

- Tracing the design
- Lettering (names, team name)
- Coloring
- Writing a description of the meaning
- Presenting the patch and description to the entire group

PRESENTATION

The whole group should meet to present their mission patches. Team should divide the presentation by task.

## Process Observation

After the presentation, teams should reassemble and conduct a Process Observation and discuss how the team is developing. Use the following Process Observation Worksheet.

# PROCESS OBSERVER WORKSHEET

HOW WELL DID THE GROUP WORK TOGETHER?

DID EVERYONE TALK?

DID SOME TALK MORE THAN OTHERS?

WAS ANYONE BOSSY?

DID SOMEONE ACT LIKE A LEADER?

DID THE REST OF THE TEAM FOLLOW?

WAS THERE ANY ARGUING?

DID THE TEAM GET FINISHED?

# Lesson 1 Shared Learning

1 Gove 3 reasons a team may be better that just one person.
2 Which of the following is NOT one of the Foundation Five?
Walk the Telk
Be part of the solution, not part of the problem.
Speak only when spoken to.
Value another's views and worth.
3 Which 4 processes are used in making a team decision?
4 Why did the USA go to the moon?
5 What are 3 differences between the Earth and the moon?

# Lesson 2

| Lesson | **Title** | **Topics** | **Time (Min)** |
|---|---|---|---|
| 2 | **Why Build a Base on the Moon?** | **Check in and Check out Introduction**<br>**Science**<br>**Biology**, How people survive in space, nutrition, air pressure, oxygen, water<br>**Agriculture**, How to grow food in space<br>**Astronomy**, How to study space with large telescopes<br>**Geology,** Mining the moon, rocks and minerals<br>**Engineering,** Construction with little gravity<br>**Social Studies**<br>Government, how will the base be governed? Law, Earth law or new laws?<br>Ethics, Right and Wrong on a closed base<br>Check out | **5**<br><br>**10**<br><br>**5**<br>**5**<br><br>**5**<br><br>**5**<br><br>**15**<br><br><br><br>**5** |

# OBJECTIVES

Students will understand Check in and Check out procedures

Students will be able to name four sciences that can be done on the moon

Students will be able to name one form of governing structure for the base

# Standards

See program reference Standards Document

## Introduction to Team Check In and Check Out (TEAMING)

**Process Observation is like taking the temperature of the team after the completion of a project. But there are quick ways to check daily about team health. The Check In and the Check Out**

**Check In**

**Check In should start every team meeting. It can be very short, but allows each member to say something, and to let the team know where he/she may be coming from that day. This helps the team accommodate any specific needs.**

**The Check In can also be used to clarify expectations for the lesson or session. A Check In is usually a response to a question. Sample questions include:**

***"How are you feeling today?"***

***"Name one thing you learned at the last session."***

***"Is there anything you would like to share before we get started?"***

***"What do you want to get out of this session?"***

**Using Check In may surface some issues the team needs to deal with before work can begin.**

# DAILY CHECK IN FORM

Select one of the most helpful questions to the team and record significant responses. If there is an issue with one or more members that needs to be addressed before the session begins, state the comment or observation and ask the team to discuss.:

____ ***“How are you feeling today?”***

____ ***“Name one thing you learned at the last session.”***

____ ***“Is there anything you would like to share before we get started?”***

____ ***“What do you want to get out of this session?”***

---

***TEAM NAME*** ***DATE***

| Member | Comment or issue |
|---|---|
| | |
| | |
| | |
| | |
| | |

## Check Out

**Check Out serves as closure for a team session. At the end of the session, the Check Out can reinforce an assignment, help clarify the level of learning in the session, identify things to be addressed at the next meeting. One good rule is to let members take a "pass" if they have no Check Out at a session but ask them to not do that twice in a row. Sometimes, having the teams reform into a whole class for the Check Out will give the facilitator and the class an indication of how things went for everyone. That can show teams that other groups have similar issues.**

# CHECK OUT FORM

**Key Information**

**Does the team know what we will do tomorrow?**

**Is there anything you want to go over more? (learning gaps)**

**What would you like to do differently tomorrow?**

## Why build a base on the moon?

**Up to now, humans have only been able to live in Earth orbit for periods of time. If humans are to go further, they need experience building, living and working on the surface of other planets. The moon is easiest to get to. The International Space Station has had astronauts living and working for up to a year. It contains everything needed to survive outside the Earth's atmosphere. Let's take a tour and see what kinds of things astronauts do in space. Like your design challenge, the ISS can have a crew up to 10. This requires the space of about a six-bedroom house here on Earth.**

## VIDEO International Space Station

https://m.youtube.com/watch?v=zAxtRSNBXtM

**Team discussion**: What examples of engineering and technology did you see in the video?

## So why do we need a lunar base?

**1 The moon has resources for construction and life support. You don't have to bring everything up from Earth.**

**2 The moon can be a research base to test human survival on other planets.**

**3 The moon can be a base to support missions to Mars.**

**4 The moon can be a source of valuable chemicals and minerals.**

**5 The moon can be a base for astronomical research away from Earth's atmosphere and radio signal pollution.**

# What kinds of science can you do on the moon?

**BIOLOGY: Studying how humans survive**

**AIR, WATER, FOOD, FUEL**

**AIR**

**Living in space or on the moon requires understanding of what the human body needs to survive. The first requirement is air. Specifically, Oxygen and pressure. That also means that spacecraft and lunar base structures have to be "airtight" and not leak.**

**Moon rocks contain Oxygen which can be recovered through a technological process. This will mean bringing equipment to the lunar surface. So engineering, technology, and biology all work together for survival.**

**Our atmosphere puts pressure on our bodies. Air circulation keeps the carbon dioxide we breathe out from suffocating us. On the lunar base, Oxygen will have to be replaced, and carbon dioxide removed.**

**Team Inquiry: When you blow up a balloon and let it go, what forces are acting on it? (atmospheric pressure and exhaust pressure)**

**Team Inquiry: On TV when a bad guy captures someone and puts them in a closed container like a barrel or a buried coffin, they must be rescued quickly. Why? (a build up of carbon dioxide will suffocate them)**

**WATER**

**The moon has ice frozen in craters at the moon's south pole. This can provide water, Oxygen, and rocket fuel. With water and lunar soil, food can be grown, and much of the crew's needs met. Water can also be recycled and purified from our body's sweat and liquid waste.**

## Team Discussion: Why do astronauts on the International Space Station say:

**"Today's coffee is tomorrow's coffee?" (the same water they drink will be recycled)**

## FOOD (Agriculture)

**Food can be grown either in water (hydroponics and aquaculture) or in lunar soil. Grains, fruits beans, and vegetables can be produced this way. Fish, shrimp, and algae can be farmed to provide protein and vitamins.**

# OPTIONAL VIDEO

https://m.youtube.com/shorts/BTVYsdiQFP4

**FUEL**

**Water is made of atoms of Hydrogen (H) and Oxygen (O), These can be separated and used for fuel. A fuel cell which on Earth power cars, and in space have powered spacecraft, slowly recombine the Hydrogen and Oxygen which makes electricity. Hydrogen and Oxygen can also be combined as a powerful rocket fuel to resupply lunar landers, and even Mars missions.**

## Astronomy on the moon

**Astronomers on Earth look at the sky in different ways. The light we see with our eyes is only one of them. Stars, planets, and galaxies give off heat, X-rays, even radio signals. For visible light, the astronomer always has to look through the Earth's atmosphere which blurs images, has pollution, clouds, light from cities, and weather. The moon has no atmosphere, so telescopes on the moon have perfect conditions.**

**Radio astronomy uses telescopes that look like giant satellite dishes. On Earth, there are interfering radio, radar, television, and satellite transmissions that make observing difficult. The moon is an excellent place for this kind of observation.**

## VIDEO Telescopes on the moon

https://m.youtube.com/watch?v=nPJZeJCCRHU

## Geology on the moon

**The lunar rocks and minerals can be used for building materials and mined for use on Earth. Aluminum, titanium, iron, silicon, and volcanic rock are all there in large quantities. The silicon could be made into solar panels for electrical power.**

**Dark volcanic basalt makes up part of the lunar soil.**

**Team Inquiry: Examine the sample basalt packet. Describe its features. List them and compare your list with other teams.**

## Engineering on the moon

**Team discussion: Think about what builders must do to construct a house here on Earth. What kinds of engineering is required to build your lunar base? (Possible answers: building structures, leveling the building site, installing equipment,**

## Social Studies – How should the base be governed?

## Types of possible base government

**Commander (1 person makes decisions)**
**Teams with leaders (teams make decisions)**
**Teams without leaders (All members vote)**

**Team discussion: Decide on how your team thinks the base should be governed. Report to the other teams and explain why you chose that answer.**

## Laws and rules

**Brainstorm a list of laws and rules everyone in the base must follow. Remember The Foundation Five. Share your list with the other teams. Did they come up with things your team didn't think of?**

## What do you do if someone breaks a rule or commits a crime?

# Lesson 2 Shared Learning

1. Why do teams check in and check out after each session?
2. Name 4 sciences that can be studied on the moon.
3. Name one type of government that can be used on the lunar base.

# CHECK OUT FORM

**Key Information**

**Does the team know what we will do tomorrow?**

**Is there anything you want to go over more? (learning gaps)**

**What would you like to do differently tomorrow?**

# Lesson 3 Structures and Shapes

| Lesson | Title | Topics | Time |
|---|---|---|---|
| 3 | Structures and Shapes | **Check in**<br>**Engineerin**g Building systems, habitability, Earth spaces vs lunar spaces<br>**Mathematics**<br>Geometry, Shapes - Cubes. Domes, Tunnels<br>Measurement – Rectangular and circular areas<br>**Check out** | |

# OBJECTIVES

Students will be able to name the three major building systems.

Students will be able to calculate and average rectangular and circular areas.

# STANDARDS

See Program Standards document

# DAILY CHECK IN FORM

Select one of the questions most helpful to the team and record significant responses. If there is an issue with one or more members that needs to be addressed before the session begins, state the comment or observation and ask the team to discuss.:

____ ***"How are you feeling today?"***

____ ***"Name one thing you learned at the last session."***

____ ***"Is there anything you would like to share before we get started?"***

____ ***"What do you want to get out of this session?"***

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***TEAM NAME*** ***DATE***

| Member | Comment or issue |
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## Introduction to Building Systems (Engineering)

### EARTH SPACES and SYSTEMS

**Any building that supports life on Earth or the moon uses "systems."**

**Worksheet**

You have just come home to a **dark**, **cold** house and need to **make some Macaroni and Cheese** for dinner. What are the ***first five*** **things you do?**

Brainstorm a list with your team.

Item 1

Item 2

Item 3

Item 4

Item 5

Item 6

**What are the THREE "SYSTEMS" you used?**

| |
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| |
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| |

**Team discussion: Have the team give examples of each major system in their home or school or on the moon.**

**Electrical**

**Mechanical (Heat and Air Conditioning)**

**Plumbing (water)**

# Engineering Mathematics

**EARTH SPACES: (Mathematics, Engineering)**

**Identifying Living Areas:**

1. Using your home living spaces, estimate the size of these areas. This will allow you to decide how much space the team will need on the lunar base.

Sleep area (bedrooms)

Galley (kitchen)

Eating area (dining room)

Living and Recreation area (den or family room)

Waste area (the bathrooms)

2. Estimate the **length** and **width** of each room and **m**ultiply them together to get the area of the room.

3. **Add** up the areas of **all the rooms** to get the total living area of your home.

4. Add up all the areas of all the homes of the people on your team and divide that by the number in your group to get the average area needed to live on Earh.

DISCUSSION: How much space does each crew member actually need?

EARTH SPACES WORKSHEET

Team member ________________________________

| AREA | SQUARE FEET |
|---|---|
| Sleep area (bedroom) | |
| Kitchen (Galley) | |
| Eating area (dining) | |
| Recreation area (den or rec room) | |
| Living area | |
| Waste area (bathroom) | |
| Workspace (desk) | |

TEAM AVERAGE AREA (Add them up and divide by the number of team members)

| AREA | SQUARE FEET (average) | |
|---|---|---|
| Sleep area (bedroom) | | |
| Kitchen (Galley) | | |
| Eating area (dining) | | |
| Recreation area (den or rec room) | | |
| Living area | | |
| Waste area (bathroom) | | |
| Workspace (desk) | | |

## Designing the First Permanent Lunar Base

It has been decided by NASA that the base will consist of:

- **Three bigger dome structures (in two different sizes)** which have to contain living quarters (HAB), work areas (LAB), and a larger dome for life support spaces (SUPPORT).
- **Three smaller domes** will be used for medical isolation (ISO), as a shelter from deadly solar radiation storms (BUNKER), and as an airlock (AIRLOCK) to allow crew to leave the base and spacewalk on the surface.

Your team will choose the name for the base and design the layout of the structures on the lunar surface. Based on your team's design, the base will be constructed by robots and be ready for you to set up and move in.

The domes are **connected by tunnels** which you will lay out, and will be connected to **solar panels, a micro nuclear reactor, and hydrogen fuel cells for power**. **Electrical cables** will connect the power modules to the domes. A **communication dish** is included.

The process involves creating **a flat poster** using dome and tunnel shapes to plan the layout. Then the team will construct a miniature **accurate 3D model** of your layout of the site.

Each team will be provided with all poster shapes and 3D site shapes necessary to create the poster and 3D model.

**Understanding SCALE**

**Obviously, there is not enough room in your classroom to actually build an entire lunar base, so your team will build small flat and three-dimensional models. Just like model trains or model airplanes, they use the idea of "scale" where a small unit like a centimeter or an inch represents a full-size measurement of an actual building or piece of equipment.**

**Problem 1.**

**At a scale of 1 " (one inch) = 10' (ten feet), how many inches would represent a square room 40 feet on each side?**

**Problem 2**

**How many inches would represent the diameter of a 60-foot circular room?**

# Lunar Base Math

# Worksheet

**Area Formulas:**

- **Rectangle    Length X Width = Area (in square feet)**
- **Circle       Radius (half the diameter) X /radius (r squared) X pi (3.14)**

**The 3D lunar base model that your team will build has a scale of 1' (one inch) = 20 feet.**

**Domes for the model will have diameters of 1", 2", or 3"**

**Based on the scale 1" = 20 feet, calculate the following:**

**3 small domes**

**1" dome has a diameter of 20 feet and a radius of 10 feet**

**10 X 10 X pi (3.14) = ___________**

**3 larger domes**

**2" dome has a diameter of 40 feet and a radius of 20 feet**

**20 X 20 X 3.14 = ___________**

**3" dome has s diameter of 60 feet and a radius of 30 feet**

**30 X 30 X 3.14= ___________**

**Calculate the total area of each dome to identify which functions fit in which domes.**

## Lunar Base Math

## Worksheet (continued)

**TUNNELS that connect the domes have areas that are long rectangles.**

- **Rectangle    Length X Width = Area (in square feet)**

**In base design, tunnels between domes should be as short as possible to minimize the amount of air needed for the base and have fewer places where leaks could occur. The team will need to calculate the total area of all the tunnels.**

**OUTSIDE EQUIPMENT**

**For safety and space reasons, some equipment will need to be outside the domes. Power systems like a nuclear microreactor, hydrogen-oxygen fuel cells, and solar panels are examples. They will also be represented in the flat poster and on the 3D model in scale. On the poster these will be squares and rectangles. On the 3D model, cubes and boxes.**

**Cube or box    Length X Width X Height = Volume (in cubic feet)**

## LUNAR BASE NAME (OPTIONAL TEAMING exercise)

Use the team decision making process

BRAINSTORM

STUDENT NAME BASE NAME IDEA

_______________________________________________

_______________________________________________

______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

_______________________________________________

ARE ANY OF THE IDEAS SIMILAR? COULD THEY BE PUT TOGETHER?

DISCUSSION (ANALYSIS)

HOW TO SELECT (DECIDE)

RANK VOTE____ CONSENSUS_____
ALL AGREE____
LET ONE DO IT____

_______________________________________________

LUNAR BASE NAME

# Lesson 3 Shared Learning

1. Name the 3 major systems used in a building.
2. Write the formulas for:
   a. Area of a rectangle
   b. Area of a circle (a dome floor)
   c. Average of a group of areas

# CHECK OUT FORM

**Key Information**

**Does the team know what we will do tomorrow?**

**Is there anything you want to go over more? (learning gaps)**

**What would you like to do differently tomorrow?**

# LESSON 4 – Life Support Systems

| Lesson | Title | *Topics* | *Time* |
|---|---|---|---|
| 4 | Life Support Systems | ***Check in***<br>***Environmental Sciences***<br>Water, Quality, purification, recycling, Biosand Filter<br>Air, Quality experiment, filtration, Oxygen, CO2<br>Waste Management, recycling and storage<br>**Technology**<br>Power Systems) Solar, batteries, fuel cells, nuclear<br>**Check out** | ***5***<br><br>***15***<br><br>***15***<br><br><br><br>***10***<br><br>***5*** |

# OBJECTIVES

Students will be able to name three systems that will be recycled on the base.

Students will be able to name three sources of electrical power for the base.

# STANDARDS

See program standards document

# DAILY CHECK IN FORM

Select one of the questions most helpful to the team and record significant responses. If there is an issue with one or more members that needs to be addressed before the session begins, state the comment or observation and ask the team to discuss.:

____ ***"How are you feeling today?"***

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____ ***"Is there anything you would like to share before we get started?"***

____ ***"What do you want to get out of this session?"***

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***TEAM NAME*** ***DATE***

| Member | Comment or issue |
|---|---|
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# ECLSS

**ECLSS** is an acronym for **E**nvironmental **C**ontrol and **L**ife **S**upport **S**ystems. Everything you need to keep you alive on a spaceflight or on the lunar base. There are systems for:

**Air** (oxygen and air quality)

**Water** (purification for drinking, food preparation, washing, and food production)

Food

**Waste** (body waste, food waste, and trash)

**Power** (lighting, fans, appliances, pumps, and communication)

The team has already looked at these systems aa part of the equipment in buildings on Earth and on the lunar base, but they are complicated, and a failure in space could be deadly. Very sensitive instruments in a spacecraft or a lunar base are necessary to constantly monitor air and water. Food is generally safe, but waste must be sterilized, filtered, and sometimes recycled (urine).

There are some simple experiments we can do to learn about this.

## ECLSS Water Quality

**Students will have experienced a space water quality system at the Challenger Center, and in a demonstration of a sand filtration system in Week 3. Remind them that these systems will need to be in their lunar base.**

**VIDEO Water recycling on the International Space Station**

https://m.youtube.com/watch?v=BCjH3k5gODI

# ACTIVITY

## Biosand Water Filtration System Demonstration/ Experiment

### Objectives

- Explain how Biosand filters purify water.
- - Build and test a working Biosand filter.
- Analyze results and propose improvements.

### Materials

• 2-liter plastic bottle (cut in half)
• Gravel, coarse sand, fine sand
• Activated charcoal (optional)
• Coffee filter or cloth
• Contaminated water (mud + water or tea + soil)
• pH strips, turbidity tube/meter
• Gloves, safety goggles

### Procedure

1. Begin with a short video and discussion on global water scarcity and Biosand filters.
2. Explain how each filter layer works: gravel (prevents clogging), coarse sand (removes large particles), fine sand (traps smaller particles and supports biofilm), and charcoal (optional chemical filtration).
3. Students work in groups to construct their Biosand filter models using provided materials.
4. Pour contaminated water through the filter and collect the filtered water.
5. Test pH, turbidity, and other observable characteristics before and after filtration.
6. Record all results in data tables.
7. Discuss results as a class, noting improvements in water clarity and quality.
8. Students write a brief reflection on the effectiveness of their filter and how it could be improved.

### Safety

• Wear gloves and goggles when handling contaminated water.
• Do not drink the filtered water — for demonstration only.

# Biosand Water Filtration Worksheet

Name: ____________________ Date: ____________

## Part 1: Vocabulary

Define the following:

1. Filtration
2. Turbidity
3. Pathogen
4. Biofilm

## : Data Collection

Record your before and after measurements:

| Test | Before Filtering | After Filtering (averaged) | Change |
|---|---|---|---|

Tests include Total Dissolved Solids, pH, turbidity, odor, and color.

| **Test** | **Trial 1 - Before** | **Trial 2 - After** | **Trial 3 - After** | **Average Trials 2 and 3** | **Change** |
|---|---|---|---|---|---|
| **Total Dissolved Solids** | | | | | |
| **pH** | | | | | |
| | | | | | |
| | **Before** | **After** | | | |
| **Odor** | | | | | |
| **Color** | | | | | |

## ECLSS Air Quality Monitoring Experiment

A simple way to monitor air quality is using a plain paper plate coated with ordinary Vaseline Jelly. The lunar base will have air quality and humidity sensors in every dome.

**Materials: (per team)**
2 Paper plates per team
String or tape
Vaseline Petroleum Jelly
**Procedure:**

Have each team put their name on the back of their plates. Either punch holes in the plates to hang them up or use duct tape (only on surfaces it won't damage). or painter's tape. Cover the plates in a patterned coating of the jelly. The pattern could be either an X pattern or a circle of jelly around the rim at least 2 inches from the edge.

Hang the plates in two different locations inside the school and outside on a busy street. Leave them in place and monitor in one week or two weeks. You should see particles sticking to the jelly.

**EXPERIMENT VIDEO Air Quality** 11:35 AM (13 minutes ago)

https://m.youtube.com/watch?v=9uVdi-3AqRE

**Team Discussion:** How does the inside air quality compare to the outside air quality?

## VIDEO Handling Carbon Dioxide (CO2)

https://m.youtube.com/watch?v=5ziFgao91hI

## VIDEO Air quality

https://m.youtube.com/watch?v=GCLxV59069E

**Waste, yes, waste**

**Humans create waste. They go to the bathroom, create trash, sweat, and breathe out carbon dioxide. We've already seen that sweat, wash water, and liquid waste can be recycled into absolutely pure water and reused over and over again. Solid body waste requires special handling. In space it can't be thrown out. There's an international space law about that. But it can be collected and burned up in the atmosphere at 17,000 miles per hour or brought back to Earth.**

**The moon will require either a burial of waste or a septic tank with water recycling and burial. Going to the bathroom in the moon's lower gravity will still require equipment similar to space toilets.**

## VIDEO **Space Bathroom**

https://www.youtube.com/watch?v=P4yZ6i8Vpig

## Powering the Base (Technology)

**The Earth rotates every 24 hours. Solar power provides electricity for only 8 to 10 hours, then we need giant batteries, or a fossil fuel backup for the nighttime. The moon only rotates only once every 28 DAYS. So solar power can be used for half a month, and emergency batteries can be used in a crisis, but other sources of power are necessary.**
**There is no wind and no water for power, so the best options are nuclear power, and renewable chemical power.**
**Small nuclear reactors (micro reactors) which generate power continuously are already being designed for use on the moon, so they will be ready for the base when built.**

**VIDEO Lunar Nuclear Power**

https://m.youtube.com/watch?v=U7yyOQoSknw

**Fuel Cells are a source of renewable power. During the 14 day long lunar day, solar cells can be used to separate water into Hydrogen and Oxygen. During the 14-day lunar night, the fuel cells recombine Hydrogen and Oxygen in a controlled process which makes electricity and water. They can also be used for emergency backup power.**

**VIDEO Fuel Cells in Space**

https://www.youtube.com/watch?v=7PBLz01Ji7c&t=13s

**Students will be able to name three systems that will be recycled on the base.**

**Students will be able to name three sources of electrical power for the base.**

# Lesson 4 Shared Learning

1. All of the following will be recycled on the moon except:
    a. Water
    b. Trash
    c. Oxygen

2. All of these can be used to power the lunar base except:
    a. Solar panels
    b. Nuclear power
    c. Natural gas
    d. Fuel cells

# CHECK OUT FORM

**Key Information**

**Does the team know what we will do tomorrow?**

**Is there anything you want to go over more? (learning gaps)**

**What would you like to do differently tomorrow?**

# LESSON 5 Construction on the moon

| Lesson | Title | **Topics** | **Time** |
|---|---|---|---|
| 5 | Construction on the Moon | **Check in**<br>**Science** Resource Production and Management, O2, Hydrogen, He3,<br>**Technology** Mining processes and construction<br>**Mathematics** Weights on the moon<br>**Engineering**, Structures, Functions, and Dimensions<br>**Check out** | **5**<br>**10**<br><br><br>**5**<br><br>**10**<br><br>**15**<br><br>**5** |

# OBJECTIVES

Students will be able to name three things that can be made on the moon.

Students will be able to calculate their weight in lunar gravity.

Students will be able to name and describe 6 structures and their dimensions to be used in their base design.

# STANDARDS

**See** program standards document

# DAILY CHECK IN FORM

Select one of the questions most helpful to the team and record significant responses. If there is an issue with one or more members that needs to be addressed before the session begins, state the comment or observation and ask the team to discuss.:

____ ***"How are you feeling today?"***

____ ***"Name one thing you learned at the last session."***

____ ***"Is there anything you would like to share before we get started?"***

____ ***"What do you want to get out of this session?"***

---

***TEAM NAME*** ***DATE***

| Member | Comment or issue |
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# Things we can get on the moon

**(And don't need to bring from Earth)**

Unlike an orbital spacecraft, the lunar soil has much of the basic elements and materials needed to sustain a crew on the base, and even support missions beyond the moon. The constant bombardment by solar wind (high energy particles streaming from the Sun) has made the moon rich in a form of Helium called Helium 3. This isn't the same kind of helium we use to fill balloons on Earth, but it is a perfect fuel for nuclear fusion reactors which can be key to making clean energy and protect Earth's environment.

## VIDEO Mining on the moon

https://m.youtube.com/watch?v=YWiRuyhjEZ8

## VIDEO Helium 3 – More valuable than gold

https://m.youtube.com/watch?v=wiHT-DjJl28

## Construction

There are many things we have to think about in construction. Here is a video tutorial. (There are commercials that must be skipped.

## VIDEO Construction processes

https://m.youtube.com/watch?v=ATgwz_hS3Qg

# WEIGHT ON THE MOON (Mathematics)

**The lower gravity on the moon is both useful and a problem. Useful because it is easier to move heavy objects like supply or water containers. And a problem because it would be harder to work with less gravity to hold machinery down, and the human body would still have physical weakening and other side effects.**

**Just how much do things weigh on the moon? How much would you weigh on the moon? The amount of matter or atoms in your body would be the same, but the moon's gravity would only make you feel one-sixth as heavy. To calculate your weight on the moon, or the weight of something you have to lift, you simply multiply the weight on Earth by one-sixth, or its decimal form .16 (point 16 or 16 one-hundredths. As an example, lifting a 100 pound battery on the moon would only feel like it weighed 16 pounds. Try this for your team members. Record the data below.**

| Team Member | Weight on Earth | Weight on the moon |
|---|---|---|
| | | |
| | | |
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# Lunar Base Spaces Tables

## What do you need in each dome?

Notes: The crew can work in shifts; sf = square feet; **VAN = Varies As Needed**

Living Spaces – HAB DOME

| Space | Equipment | Number of crew | Total sf needed |
|---|---|---|---|
| Food preparation and dining | Sink, microwaves, folding chairs | 10 | 300 |
| Sleep | *Bunks* | 15 sf each for 10 crew | 150 |
| 3 bathrooms | *Toilet, Sink* | 15 sf each for 3 bathrooms | 45 |
| Common Area | Living room furniture, entertainment systems, etc. | 10 | 250 |
| Personal space | Work surface, computer, chair | 12.5 sf each for 10 crew | 125 |
| Exercise area | 3 Treadmills, 3 Exercycles, Weightlifting Equipment | | 225 |
| Food storage (daily use) | Cabinets | | 20 |
| TOTAL HAB DOME | | | 11165 |

Workspaces -Combined OPS and LAB DOME

| Space | Equipment | Number of Crew | Total sf needed |
|---|---|---|---|
| Master Control | VAN | 2 | 100 |
| Geology Lab GEO | VAN | 2 Per workstation | 150 |
| BIO Lab (testing) | VAN | 2 | 150 |
| Computer and Repair Lab COMP | VAN | 4 | 300 |
| Infirmary- Med Lab | VAN | 4 | 400 |
| TOTAL LAB DOME | | | 1100 |

Life Support Equipment -SUPPORT DOME

| Space | Equipment | Number of Crew | Total sf needed |
|---|---|---|---|
| **Food Production:**<br>Lunar soil crops<br>Hydroponic crops<br>Aquaculture tanks | VAN | VAN | <br>800<br>400<br>500 |
| Maintenance Shop | VAN | VAN | 400 |
| Water Storage & recycling (2 X 500 gallons) | VAN | VAN | 200 |
| Space suits storage | | | 200 |
| TOTAL SUPPORT DOME | | | 2500 |

External Equipment

| System/ Part | Dimensions for 3D model |
|---|---|
| Solar Panels 4 banks (rows) 160 kW | 10 X 80 feet each (1/2" X 4" scale) |
| Micro Nuclear Reactor 1MW | 10 foot cube (1/2" X1/2"X1/2" scale) |
| 10 foot Earth communication dish | ½ " dish |
| Fuel Cells 4 1 kW each | ½"X1/4'X ¼" scale ( Yellow |
| Connector tunnels 10 feet wide, variable lengths | ½" wide variable length |
| Power connection cables | Wire from power units to domes |

# LAB DOME ACTIVITIES

## Information Sheet

| |
|---|
| Master Control – Communication and monitoring center for the base. Monitoring air quality, air pressure, water quality, temperature, and electrical circuits for the whole base. The Master Control also is the hub for communication in all the domes, to spacecraft operations, and communications to Earth. |
| Geology Lab GEO -The GEO Lab is where testing is done to help with lunar mining operations, water extraction from surface ice, and geological research on the history of the moon. |
| BIO Lab (testing) – The BIO Lab is where testing is done to check water quality, crew health testing, crop and food health and quality, and waste management testing. |
| Computer and Repair Lab – COMP Lab is where computers and electronics are serviced, software is upgraded, motors, fans, and pumps are tested, and hardware upgrades are installed. |
| Infirmary- Med Lab is where noncontagious injury and disease are treated, diagnostic tests are run, and general health checkups are done. |

# Lesson 5 Shared Learning

1. Astronauts will be able to get the following materials from lunar soil:
    a. Helium 3
    b. Oxygen
    c. Water
    d. Building bricks
    e. All of the above
2. A 200 pound fuel cell would feel like it weighed ______ pounds on the moon.
3. Which of the following is NOT one of the domes in the base?
    a. Lab dome
    b. Supply dome
    c. Airlock dome
    d. Instrument dome
    e. Hab dome

# CHECK OUT FORM

**Key Information**

**Does the team know what we will do tomorrow?**

**Is there anything you want to go over more? (learning gaps)**

**What would you like to do differently tomorrow?**

# LESSON 6 Designing the base layout

| Lesson | Title | **Topics** | **Time** |
|---|---|---|---|
| 6 | Designing the base layout | **Check in** | **5** |
| | | **Art and Design** sketching ideas – layout overview | **10** |
| | | **Problem Solving**, Finding solutions with constraints | |
| | | **Project Planning**, Roles and responsibilities, collaboration | **5** |
| | | **Mathematic**s Scale, Measurement, coordinates | **5** |
| | | **Poster Production** | **15** |
| | | **Process Observation** | **5** |
| | | **Check out** | **5** |

# OBJECTIVES

Students will experience a team design process from planning to creation of a poster.

Students will be able to use scale and measurement to place components in their design.

Students will complete a Process Observation as a diagnostic of team health and effectiveness.

# STANDARDS

See program standards document

# DAILY CHECK IN FORM

Select one of the questions most helpful to the team and record significant responses. If there is an issue with one or more members that needs to be addressed before the session begins, state the comment or observation and ask the team to discuss.:

____ ***"How are you feeling today?"***

____ ***"Name one thing you learned at the last session."***

____ ***"Is there anything you would like to share before we get started?"***

____ ***"What do you want to get out of this session?"***

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***TEAM NAME*** ***DATE***

| Member | Comment or issue |
|---|---|
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| | |

## LUNAR BASE SCHEMATIC LAYOUT OVERVIEW

Engineers create diagrams of their designs so that builders can construct them. The process involves adding the total required footage for the major spaces and deciding how to place them inside the structures. For astronauts spending long times on the moon, it is important that, since they can't easily take walks outside when they feel closed in, to spend as much time as possible in the larger spaces.

This base has:

- 1 60 foot diameter dome (3 inches in our 3D scale),
- 2 40 foot diameter domes (2 inches), and
- 3 20 foot diameter domes (1 inch) for things that need to be isolated like a solar radiation storm bunker, contagious disease isolation unit, and the airlock for outside surface activity.

Since the domes are pressurized, they are connected by pressurized tunnels for quick access. The large dome is the size of a four- or five-bedroom house. The medium sized dome is the size of a two-bedroom apartment, and the small dome is the size of a large living room.

## THINGS TO THINK ABOUT

- Small domes (20-foot diameter or 1 inch in scale) are **single** function domes (Emergency Shelter, Medical Isolation, Airlock)
- Tunnels should be **as short as possible** because they also must be pressurized for quick travel between areas and minimum Oxygen volume requirement..

# Lunar Base 2D site plan poster kit supplies

**24”X 24” cardboard base**
**Scale 1”=10 feet**

**Domes**
**1-  6” diameter circle**

**2- 4” diameter circles**

**3- 2” diameter circles**

**3/4” wide strips for connecting tunnels to be cut to length**

**4- 1/2” X 8” solar panel strips**

**1- 1” X 1” square Micro Nuclear Reactor**

**1- 1” circle Earth communication dish**

**4- 1/2” X 1/2” fuel cells**

**Power cables can be drawn with a black marker**

# LUNAR BASE LAYOUT OPTIONS

## Designing the Layout

## Step 1

. The team now creates a small drawing of how they want the domes, tunnels, and outside equipment arranged. Remember the domes need to be connected by pressurized tunnels. The tunnels should be as short as possible.

### Possible arrangements.

- **Straight line**
  - Simple, but you must go through every dome to get anywhere
- **Circular (like an African village)**
  - Simple but tunnels would be long and possibly confusing
- **Radiating (like a wheel with a hub and spokes)**
  - Central dome as a hub with spokes or two hubs connected with a short tunnel and other domes radiating out.
- **Other – Create your own custom layout**

## Step 2

Working in pairs, sketch your ideas for the dome arrangement. Share them with the other pairs and **discuss**. Use your decision-making process to **decide** on which configuration the whole team will use.

# BASE DESIGN SELECTION WORKSHEET

STUDENT NAME BASE DESIGN IDEA

______________________________________________________

______________________________________________________

_____________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

______________________________________________________

ARE ANY OF THE DESIGNS SIMLAR? COULD THEY BE PUT TOGETHER?

DISCUSSION (ANALYSIS)

HOW TO SELECT (DECIDE)

RANK VOTE____ CONSENSUS_____
ALL AGREE____
LET ONE DO IT____

______________________________________________________

BASE DESIGN SELECTION

## Step 3

Reassemble as a whole team and compare the design ideas. Discuss and decide on the whole team's solution. Make a clean drawing of the final **dome and tunnel** arrangement. Then add and label other parts of the base:

The solar panel array

The Micro- Nuclear Reactor

The Fuel Cell power backup

The resupply landing pad

Power cables to the domes

Satellite Dish to communicate with Earth

**YOU ARE NOW READY TO CREATE YOUR DISPLAY POSTER!**

# Implementing the TEAMING Planning Process

## Facilitator Guidance

In the example of designing the Lunar Base, the team might first want to address the issues of team structure, work organization, responsibilities and resources. As an example, the team might do an inventory of relevant skills of its members (Generate Ideas), then the skills they think they will need to design the widget (Generate Ideas). These can then be placed side by side and Prioritized. Any differences or deficiencies can then be Analyzed, and the team can then Decide if deficiencies can be made up with additional members, expert advisors, training, or reference material. At any time, if a Decision is required within this process, the team simply works quickly through the Team Decision Making Model.

When planning **work flow**, the team needs to consider the time available, then, use the Planning Process to generate ideas on how to use the time, prioritize its tasks, analyze the work flow elements to make sure they are realistic and finally decide on the actual schedule for the project. While this process may seem very formal, and even tedious, experienced teams can work through these steps in a very few minutes. The steps become habits. The steps help team organization. The steps help the team use its time better. The steps provide a structure that also reduces the possibility of friction or disagreement, since all team members get a chance to have input to every stage of team planning.

The decisions can then be organized and prioritized in a “Team Plan” which outlines the timeline, tasks, and responsible team member(s) For the Lunar Base Challenge, all activities will be done immediately and last only the three periods building the 2D Poster and the D model.

# TEAMING

## Team Plan

| WHEN (Start or Due Date) | WHAT (Task) | WHO (Team Member) |
|---|---|---|
| This activity is only a one-day process and starts now. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |
| 6. | | |
| 7. | | |
| 8. | | |

# LUNAR BASE LAYOUT 2

**Step 4 POSTER PRODUCTION**

**NOTE: the 3D model will use a scale of 1-inch equals 20 feet. To be easier to see and explain in your presentations, the poster uses a scale of 1-inch equals 10 feet.**

Using the 24” X 24” piece of cardboard as a base. Cut out the shapes from the Lunar Base component sheets. The team needs to create the layout and cut tunnels to fit between the domes. Once the final layout is agreed, glue each piece to the cardboard.

This poster will be used in your team’s final presentation where team members will explain why this layout was chosen, what goes on in each dome, and how the crew operates. The layout will then be used to place the parts on your 3D model of the actual base.

**Be sure to put the name your team selected for the base at the top of the poster and your team name at the bottom.**

**Questions you should be able to answer**:

What goes on in each dome?

How did the team decide the layout of the base?

Why were the domes placed where they are? (for example: easy access, quick access for emergencies)

# DATA SHEET: LUNAR BASE DESIGN

## LUNAR BASE DOME FUNCTIONS

**Living Areas (HAB)**

Food preparation and Dining
Sleeping and Bathroom
Common living space
Personal space

**Work Areas (LAB)**

Laboratories (Medical, Geological, Biological, Computer)
Repair Shop (Spare parts, 3D printers, Tools)
Experiment Control (Lab equipment, Experiment racks)
Master Control (Communications hub, Systems monitors)
Storage (Emergency rations, extra batteries, clothing)

**Support Dome (SUPPORT)**

Food production
Water purification
Oxygen production
Master power control
Storage (fuel, backup equipment, emergency rations)

**Base Electrical Power**

Solar panels (60 X 60 panel area provides 180 kilowatts)
Nuclear Micro-reactor 1 Megawatt)
Fuel Cells (4000 watts emergency power)
Radiators (keep equipment cool)
Fuel storage (Hydrogen and Oxygen tanks)

# PROCESS OBSERVER WORKSHEET

HOW WELL DID THE GROUP WORK TOGETHER?

DID EVERYONE TALK?

DID SOME TALK MORE THAN OTHERS?

WAS ANYONE BOSSY?

DID SOMEONE ACT LIKE A LEADER?

DID THE REST OF THE TEAM FOLLOW?

WAS THERE ANY ARGUING?

# Lesson 6 Shared Learning

1. Which of the following is NOT part of the team planning process?
    a. Schedule of tasks
    b. Identification of team nicknames
    c. Assignment of team members to tasks
    d. Identification of tasks
2. Using a scale of 1 inch equals 20 feet, how long would a tunnel be that is 60 feet long?
3. A Process Observation includes the following:
    a. Was the task completed?
    b. Was there any conflict?
    c. Did everyone talk?
    d. A and B only
    e. A and C only
    All of the above

# CHECK OUT FORM

**Key Information**

**Does the team know what we will do tomorrow?**

**Is there anything you want to go over more? (learning gaps)**

**What would you like to do differently tomorrow?**

# LESSON 7 Building the 3D Model Part 1

| Lesson | Title | **Topics** | **Time** |
|---|---|---|---|
| 7 | Building the 3D Model Part 1 | **Check in**<br>**Project Planning**, Scale, Measurement, **Structured Activity**, Collaboration, procedures, following instructions, interesting instructions, collaboration<br>**Mathematics** scale, measurement, coordinates<br>**Check out** | **5**<br>**40**<br><br><br><br><br><br><br>**5** |

# OBJECTIVES

Students will be able to organize team roles and responsibilities to complete the 3D lunar base model.

Students will lay out the model components using the 1-inch equals 20-foot scale.

Students will follow construction procedures.

Students will report team issues in the check out.

# STANDARDS

See program standards document

# DAILY CHECK IN FORM

Select one of the questions most helpful to the team and record significant responses. If there is an issue with one or more members that needs to be addressed before the session begins, state the comment or observation and ask the team to discuss.:

____ ***"How are you feeling today?"***

____ ***"Name one thing you learned at the last session."***

____ ***"Is there anything you would like to share before we get started?"***

____ ***"What do you want to get out of this session?"***

---

***TEAM NAME*** ***DATE***

| Member | Comment or issue |
|---|---|
| | |
| | |
| | |
| | |
| | |

**Lunar Base 3D Model Kit Planning**

**Teams will assemble and identify all the parts and materials needed to complete the 3D project. Have one member responsible for recording the checklist while the other members sort the kit parts.**

| Check | Number | Item |
|---|---|---|
| | 1 | 12” X 12” gray wooden base |
| | 1 | 3 inch dome (60 foot diameter) |
| | 2 | 2 inch domes (40 foot diameter) |
| | 3 | 1 inch domes (20 foot diameter) |
| | 1 | Tunnel tubing (as needed for the design) |
| | 1 | 4” X 4” (60 foot square) Solar Panel |
| | 1 | Micro Nuclear Reactor (1inch cube) |
| | 1 | Fuel Cell power backup (1 inch cube) |
| | 1 | 3-inch black Resupply Landing Pad |
| | 1 | Satellite communication dish |
| | 1 | Wires – Power cables connecting to domes |
| | 1 | Tube model or super glue |
| | 1 | Spray glue |
| | 1 | Lunar Basalt dust package |
| | 1 | Kitchen strainer |

**Once you have all the parts, store them for the construction phase**

# 3D Model Layout

**Procedure:**

**Step 1:**

Place the 12” X 12” gray wooden base on a flat work surface covered to protect the table. Using your poster diagram as a guide, place the major components on the base.

| |
|---|
| **12” X 12” gray wooden base** |
| **1-3 inch dome (60 foot diameter)** |
| **2-2 inch domes (40 foot diameter)** |
| **3-1 inch domes (20 foot diameter)** |

**Step 2**

Cut the 1/2 inch tubing for each tunnel. Measure the distance for each tunnel segment and place it in position.

**Step 3**

**IMPORTANT!** Mark the location where the Solar Panel, the Micro-Reactor, the Landing pad, and the satellite dish will be placed. **Then** place the wire power cables on the model. The wires should run from the solar panel, the nuclear reactor and the fuel cell module locations to the nearest dome. Once there, the power would run through tunnels inside to the other domes.

**Step 4**

Carefully lift and glue each part. Have a team member **write down** each part AS IT IS GLUED. When completed, have another member check each part carefully **to be sure it is stuck tight.**

# 3D Model Layout 2

## Step 5

Prepare the lunar basalt dust. Lightly spray a coating of glue over the entire model. Then, using the kitchen strainer, shake an even layer of dust over the entire model creating an actual moonscape. Lightly blow any excess dust off the model.

## Step 6

Place the remaining equipment modules on the base.

| |
|---|
| **4 - 1/4" X 4" (60 foot square) Solar Panels** |
| **Micro Nuclear Reactor (1inch cube)** |
| **Fuel Cell power backup (1 inch cubes)** |
| **3-inch black Resupply Landing Pad** |
| **Satellite communication dish** |

Step 7

Check the model with your layout design poster to make sure everything is in the right place. **Cover with a light cloth or loose paper towels to protect it from dust.**

# Lesson 7 Shared Learning

1. Name 3 roles for team members in the model building process.
2. How much smaller are the 3D components than the 2D poster components?
3. Were there any issues the team experienced during the planning and layout? List them.

# HECK OUT FORM

**Key Information**

**Does the team know what we will do tomorrow?**

**Is there anything you want to go over more? (learning gaps)**

**What would you like to do differently tomorrow?**

# LESSON 8 Building the 3D Model Part 2

| Lesson | Title | **Topics** | **Time** |
|---|---|---|---|
| 8 | Building the 3D Model Part 2 | **Check in**<br>**Structured Activity**, Following instructions, collaboration<br>**Language Arts**<br>Presentation Preparation<br>Documentation<br>**Check out** | **5**<br>**25**<br><br>**15**<br><br><br>**5** |

# OBJECTIVES

Students will complete the 3D model.

Students will document model features and functions for a team presentation.

Students will be able to identify and describe each model component.

# STANDARDS

See program standards document

# DAILY CHECK IN FORM

Select one of the questions most helpful to the team and record significant responses. If there is an issue with one or more members that needs to be addressed before the session begins, state the comment or observation and ask the team to discuss.:

____ ***"How are you feeling today?"***

____ ***"Name one thing you learned at the last session."***

____ ***"Is there anything you would like to share before we get started?"***

____ ***"What do you want to get out of this session?"***

---

***TEAM NAME*** ***DATE***

| Member | Comment or issue |
|---|---|
| | |
| | |
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| | |
| | |

## Complete Model Construction

**If needed, finish the Lunar Base model from last week. Carefully, be sure components are still securely mounted. Cover with a light cloth  or loose paper towels to protect it from dust.**

# Presentation Documentation

**Team members: Describe each component of the base.**

**HAB Module**

**LAB Module**

**SUPPORT Module**

**ISO Module**

**AIRLOCK Module**

**SHELTER Module**

**Tunnels**

**Power and Cables**

- **Micro Reactor**
- **Solar Panels**
- **Fuel Cells**

**Science**

- **Radio Telescope**

# Lesson 8 Shared Learning

1. Team members will be able to describe the activities and functions of all six domes, and the power and science components of the base.
2. Team members will all review and be able to point out and name each piece on the 3D model.

# CHECK OUT FORM

**Key Information**

**Does the team know what we will do tomorrow?**

**Is there anything you want to go over more? (learning gaps)**

**What would you like to do differently tomorrow?**

# LESSON 9 Presenting Your Design

| Lesson | Title | Topics | Time |
|---|---|---|---|
| 9 | Presenting Your Design | **Check in**<br>**Team Presentations**<br>**Science, Technology and Engineering** Concepts<br>**Language Arts** Explanation, Public Speaking<br>**Final Process Observation**<br>**Team Appreciation** | **5**<br>**25**<br><br><br><br><br>**5**<br>**15** |

# OBJECTIVES

Students will be able to effectively describe their lunar base components and functions.

Students will communicate clearly and effectively during their presentations.

Students will be able to explain how STEM disciplines interrelated in the design of a lunar base.

Students will be able to express clearly how each team member contributed to the project.

Students will be able to articulate how they experienced the TEAMING environment.

# STANDARDS

See program standards document.

## DAILY CHECK IN FORM

Select one of the questions most helpful to the team and record significant responses. If there is an issue with one or more members that needs to be addressed before the session begins, state the comment or observation and ask the team to discuss.:

____ ***"How are you feeling today?"***

____ ***"Name one thing you learned at the last session."***

____ ***"Is there anything you would like to share before we get started?"***

____ ***"What do you want to get out of this session?"***

---

***TEAM NAME*** ***DATE***

| Member | Comment or issue |
|---|---|
| | |
| | |
| | |
| | |
| | |

**LUNAR BASE design presentations.**

Set up the room so that the teams and guests can view the finished posters and models.

**Process and content:**

**Every** team member should participate in some way. The teams should use the presentation worksheet to **decide who will present each section**, and what the important points of each section should be.

Have the teams present a 10-to-15-minute briefing exhibiting and describing their Lunar Base. They should include:

Team name and members

Base name

Base configuration

Base Mission

Total HAB living space and what that space contains

Total LAB workspaces and what those spaces contain

Total SIPPORT workspaces and what those spaces contain.

Power sources used

Point out special features of the Base

Lead applause after every presentation. After each presentation, ask **how well they thought they did as a team**. Remind them that astronauts must work well together if they are to survive in space.

# YOUR TEAM'S LUNAR BASE PRESENTATION

Your presentation should include information about the following:

TEAM NAME and members

BASE NAME and why it was chosen

Base configuration. Describe the parts.

Base Mission

Total living space and what that space contains

Total workspaces and what those spaced contain

Power sources used

Point out special features of the Base

# Summary Process Observation

**For this exercise. The team needs to think about the WHOLE experience from the beginning of the program.**

**Part 1**

**How well did the group work together? (Five specific examples)**

**Did everyone participate?**

**Did some talk more than others?**

**Was anyone bossy?**

**Did different team members lead at different times?**

**Part 2**

**Did the rest of the team follow?**

**Was there any arguing?**

**Did the team finish all its work each day?**

**What things have you learned about members of your team?**

## TEAM FAREWELL

**Ask each member of your team to write down something they appreciate about every other member.**

**It could be a specific time they were helpful,**

**a time they came up with a good idea,**

**a time they used one of the Foundation Five ground rules,**

**a particular skill or talent that helped them or the whole team,**

**a compliment they gave,**

**their helpful attitude,**

**their keeping the team focused,**

**their willingness to share ideas,**

**a funny remark,**

**a smile**

**.**

**Then, have each member read their list to their fellow team members and THANK THEM.**

# PRESENTATION OF COMPLETION CERTIFICATES

# Appendix – Standards and Benchmarks

Aerospace Education Impact Center

# Lunar Base

# Design Challenge

## Standards and Benchmarks

### Comprehensive STEM Education -TEAMING (CSET)

### (Middle School Version)

# Standards and Benchmarks

## Comprehensive STEM Education -TEAMING (CSET)

### Understanding standards in the CSET environment

**CSET is the next generation STEM classroom curricular model. It incorporates a “whole curriculum” approach helping students understand how STEM subjects, which are traditionally stove piped, are integrated and multi-disciplinary.**

**A key feature of this pedagogy is that it mirrors the integrated skill sets needed for today’s STEM workplace. The seamless inclusion of a workplace modelled team-based approach (TEAMING) reinforces the strength of this School-to Work skills curriculum.**

**Applying standards in this environment requires some adaptation. In the scope and sequence of traditional curricula, standards are often limited to a specific subject in a specific lesson. The CSET environment expands to include multi-disciplinary standards within the same lesson. In addition, CEST overlays national Technology standards in virtually all lessons.**

**TEAMING introduces Interpersonal and Intragroup skills which are a part of virtually every contemporary workplace.**

# Lesson 1 – Standards and Benchmarks (Full DOE Style)

## Lesson Title: The Challenge & Your Team

### Science: SC.6.E.5.3

Full Standard: Describe the role of space exploration in advancing scientific understanding.
Benchmark Clarifications:

- Explains how technology expands scientists' ability to study space beyond Earth.
- Identifies major space missions and what they taught us (e.g., Apollo Program).

Connection to Lesson:
Students learn about space missions and teamwork within NASA-style challenges.

### Science: SC.6.N.1.1

Full Standard: Conduct systematic observations and investigations.
Benchmark Clarifications:

- Uses step-by-step procedures during collaborative investigations.
- Collects and records data when evaluating team processes.

Connection to Lesson:
Students observe, plan, and organize team roles using basic scientific inquiry behaviors.

### Mathematics: MA.6.GR.1.1

Full Standard: Identify relationships among geometric figures and solve simple geometric problems.
Benchmark Clarifications:

- Classifies shapes by sides, angles, and attributes.
- Uses properties of shapes when planning model structures.

Connection to Lesson:
Students begin considering the shapes they will later use in the lunar base design.

### ELA: ELA.6.C.1.4

Full Standard: Write expository texts using relevant evidence and logical organization.
Benchmark Clarifications:

- Organizes writing into clear sections (intro, body, conclusion).

• Uses facts or examples to support ideas.
Connection to Lesson:
Students write mission explanations and describe the purpose of their team roles.

## ELA: ELA.6.C.2.1

Full Standard: Deliver oral presentations using appropriate structure and details.
Benchmark Clarifications:
• Speaks clearly and stays on topic.
• Uses pacing and expression appropriate for the audience.
Connection to Lesson:
Students present their mission team responsibilities to the class.

## Social Studies: SS.6.W.1.3

Full Standard: Interpret past events and their significance.
Benchmark Clarifications:
• Connects past space missions to present-day exploration.
• Explains how historical achievements influence modern space programs.
Connection to Lesson:
Students explore how past space missions influence modern aerospace teamwork.

## Physical Education: PE.6.L.3.1

Full Standard: Demonstrate teamwork and cooperation during group activities.
Benchmark Clarifications:
• Works respectfully with teammates.
• Uses positive communication and shared responsibilities.
Connection to Lesson:
Lesson 1 is centered on effective teamwork and mission collaboration.

## CTE–STEM: CTE-STEM.68.TE.01

Full Standard: Apply the engineering design process to solve technological problems.
Benchmark Clarifications:
• Defines the design challenge clearly.

• Begins brainstorming possible mission approaches.

Connection to Lesson:

Students begin the engineering design cycle by establishing mission goals and constraints.

## ITEEA Standard: STL 1

Full Standard: Understand the characteristics and scope of technology.

Benchmark Clarifications:

• Recognizes technology as human-made solutions to problems.
• Understands that technologies evolve as needs change.

Connection to Lesson:

Students identify the technological systems needed for a lunar mission.

## ITEEA Standard: STL 9

Full Standard: Understand engineering design.

Benchmark Clarifications:

• Uses iterative methods to identify problems and solutions.
• Understands that design involves teamwork and creativity.

Connection to Lesson:

Students engage in problem identification and team-based design thinking.

# Lesson 2 – Standards and Benchmarks (Full DOE Style)

## Lesson Title: Why Build a Base on the Moon?

### Science: SC.7.L.17.3

Full Standard: Compare resource availability and the survival needs of organisms in different environments.
Benchmark Clarifications:
• Identifies which resources are required for human survival.
• Explains how limited resources affect survival on the Moon.
Connection to Lesson:
Students identify what humans need to survive and compare Earth vs. lunar environments.

### Science: SC.8.E.5.10

Full Standard: Identify objects and resources in the solar system and compare their characteristics.
Benchmark Clarifications:
• Recognizes the Moon as a location with unique resources such as regolith and ice.
• Explains how these resources can support human life.
Connection to Lesson:
Students evaluate potential lunar resources that justify building a moon base.

### Mathematics: MA.7.DP.1.1

Full Standard: Analyze and interpret real-world data.
Benchmark Clarifications:
• Examines survival-related data sets (oxygen, food, water).
• Draws conclusions based on resource data.
Connection to Lesson:
Students analyze life-support data to determine feasibility for colonization.

### ELA: ELA.6.C.1.4

Full Standard: Write expository texts using relevant evidence and logical organization.
Benchmark Clarifications:
• Develops a clear explanation supported with facts.
• Uses evidence about survival and resources.

Connection to Lesson:
Students write explanations about why humans should build a lunar base.

## ELA: ELA.6.C.4.1

Full Standard: Conduct research using multiple sources.
Benchmark Clarifications:
• Uses appropriate keywords to find relevant science information.
• Evaluates reliability of sources.
Connection to Lesson:
Students research NASA data, survival needs, and lunar conditions.

## Social Studies: SS.7.E.1.3

Full Standard: Explain how economic choices affect the allocation of scarce resources.
Benchmark Clarifications:
• Evaluates trade-offs in resource usage.
• Assesses how limited supplies determine decision-making.
Connection to Lesson:
Students consider economic decision-making when determining lunar base priorities.

## Social Studies: SS.6.G.5.1

Full Standard: Describe human–environment interactions.
Benchmark Clarifications:
• Explains how humans adapt to or modify extreme environments.
• Connects environmental conditions to engineering needs.
Connection to Lesson:
Students identify environmental challenges and how humans adapt to lunar conditions.

## Physical Education: PE.7.R.5.1

Full Standard: Demonstrate cooperative strategies in small-group settings.

Benchmark Clarifications:
• Uses planning skills to complete group tasks.
• Communicates clearly to solve problems.

Connection to Lesson:
Students work collaboratively in resource-ranking and survival tasks.

## CTE–STEM: CTE-STEM.68.TE.03

Full Standard: Evaluate technological solutions.
Benchmark Clarifications:
• Identifies criteria and constraints related to survival.
• Evaluates the effectiveness of potential life-support solutions.
Connection to Lesson:
Students evaluate survival systems and technological solutions for a lunar base.

## CTE–STEM: CTE-STEM.68.TE.02

Full Standard: Analyze systems engineering concepts and subsystems.
Benchmark Clarifications:
• Identifies subsystems such as air, water, and shelter.
• Explains how each subsystem supports human survival.
Connection to Lesson:
Students analyze survival systems needed for a functional lunar base.

## ITEEA Standard: STL 2

Full Standard: Understand core concepts of technology.
Benchmark Clarifications:
• Recognizes resources, tools, and processes used in technology.
• Understands constraints and trade-offs in technological choices.
Connection to Lesson:
Students analyze how limited lunar resources shape the design of a moon base.

## ITEEA Standard: STL 13

Full Standard: Understand engineering in the designed world.
Benchmark Clarifications:
• Describes technologies developed to support human life.
• Explains how engineering addresses challenges in extreme environments.
Connection to Lesson:
Students explore engineering solutions to survive and thrive on the Moon.

# Lesson 3 – Standards and Benchmarks (Full DOE Style)

## Lesson Title: Moon Environment & Human Survival

### Science: SC.6.E.7.5

Full Standard: Explain how various atmospheric conditions and surface features affect life and materials.
Benchmark Clarifications:
• Identifies extreme lunar conditions (temperature, no atmosphere, radiation).
• Explains why specialized protection and materials are needed for survival.
Connection to Lesson:
Students analyze environmental hazards on the Moon and determine survival requirements.

### Science: SC.6.L.15.1

Full Standard: Describe how environmental factors and available resources affect survival.
Benchmark Clarifications:
• Explains human survival needs such as air, water, shelter, and temperature regulation.
• Compares how these needs differ between Earth and the Moon.
Connection to Lesson:
Students evaluate which life-support systems are needed on a lunar base.

### Mathematics: MA.6.DP.1.2

Full Standard: Summarize numerical data sets using measures of center or variation.
Benchmark Clarifications:
• Interprets environmental data such as temperature ranges.
• Analyzes variation to determine safe survival thresholds.
Connection to Lesson:
Students use Moon temperature data to determine design constraints.

### ELA: ELA.6.C.1.3

Full Standard: Write informational texts that convey ideas clearly.
Benchmark Clarifications:

• Uses focused paragraphs to explain environmental dangers.
• Includes scientific evidence to support explanations.
Connection to Lesson:
Students write descriptions of lunar hazards and explain why protection is required.

## Social Studies: SS.6.G.1.3

Full Standard: Interpret scale and spatial relationships on maps and globes.
Benchmark Clarifications:
• Uses scale to understand distances on the Moon.
• Explains how location affects exposure to environmental hazards.
Connection to Lesson:
Students identify safe areas on the Moon for establishing a base.

## Physical Education: PE.6.R.5.2

Full Standard: Apply safety procedures during group tasks.
Benchmark Clarifications:
• Demonstrates understanding of safe practices.
• Maintains awareness of hazards during group investigations.
Connection to Lesson:
Students model safe-handling procedures during survival demonstrations.

## CTE–STEM: CTE-STEM.68.TE.05

Full Standard: Apply engineering concepts to material selection.
Benchmark Clarifications:
• Identifies materials suitable for extreme temperatures.
• Explains trade-offs such as weight vs. protection.
Connection to Lesson:
Students analyze materials needed for survival suits and habitats.

## ITEEA Standard: STL 20

Full Standard: Understand construction technologies used to build structures.
Benchmark Clarifications:
• Recognizes forces and constraints affecting construction in hostile environments.
• Explains how structures are adapted for safety.

Connection to Lesson:
Students examine construction requirements for a lunar base under extreme conditions.

# Lesson 4 – Standards and Benchmarks (Full DOE Style)

## Lesson Title: Mapping & Base Layout

### Mathematics: MA.6.GR.1.3

Full Standard: Plot points on the coordinate plane to solve real-world problems.
Benchmark Clarifications:
• Identifies ordered pairs on a grid.
• Uses coordinate relationships to create accurate layouts.
Connection to Lesson:
Students map the lunar base using coordinate grids.

### Science: SC.6.E.7.9

Full Standard: Describe patterns in the Sun–Earth–Moon system.
Benchmark Clarifications:
• Explains shadow cycles.
• Connects sunlight patterns to base placement.
Connection to Lesson:
Students identify safer, stable locations for base construction.

# Lesson 5 – Standards and Benchmarks (Full DOE Style)

## Lesson Title: Life Support Systems

### Science: SC.6.L.15.1

Full Standard: Describe how environmental factors affect survival.
Benchmark Clarifications:
• Identifies human survival needs.
• Explains system requirements for survival.
Connection to Lesson:
Students design air, water, and food systems.

### CTE–STEM: CTE-STEM.68.TE.02

Full Standard: Analyze systems engineering concepts.
Benchmark Clarifications:
• Identifies subsystems.
• Explains interdependence of life-support components.
Connection to Lesson:
Students build integrated life-support subsystems.

# Lesson 6 – Standards and Benchmarks (Full DOE Style)

## Lesson Title: Power & Energy Systems

### Science: SC.8.P.9.1

Full Standard: Classify matter by its physical properties.
Benchmark Clarifications:
• Evaluates materials for energy collection.
• Explains conduction/radiation impacts.
Connection to Lesson:
Students analyze materials for solar panels and batteries.

### ITEEA Standard: STL 23

Full Standard: Understand energy and power technologies.
Benchmark Clarifications:
• Identifies power systems.
• Explains storage/distribution.
Connection to Lesson:
Students design solar energy systems for the lunar base.

# Lesson 7 – Standards and Benchmarks (Full DOE Style)

## Lesson Title: Structures & Materials

### Science: SC.7.P.11.2

A. Full Standard: Investigate how forces affect motion and stability.
B. Benchmark Clarifications:
   - Identifies structural forces.
   - Explains stability in low gravity.
C. Connection to Lesson:
D. Students test habitat shapes and reinforcement strategies.

### CTE–STEM: CTE-STEM.68.TE.05

Full Standard: Apply engineering to material selection.
Benchmark Clarifications:
• Chooses materials based on safety and strength.
• Evaluates trade-offs.
Connection to Lesson:
Students choose materials for habitat construction.

# Lesson 8 – Standards and Benchmarks (Full DOE Style)

## Lesson Title: Model Construction

### CTE–STEM: CTE-STEM.68.TE.06

Full Standard: Use tools and technologies safely.
Benchmark Clarifications:
• Uses cutting tools properly.
• Follows safety protocols.
Connection to Lesson:
Students build their physical lunar base models.

### ITEEA Standard: STL 11

Full Standard: Apply design processes using models.
Benchmark Clarifications:
• Uses sketches to guide construction.
• Improves designs iteratively.
Connection to Lesson:
Students refine and assemble final models.

# Lesson 9 – Standards and Benchmarks (Full DOE Style)

## Lesson Title: Final Presentation & Reflection

### ELA: ELA.6.C.2.1

Full Standard: Deliver oral presentations with appropriate structure and detail.
Benchmark Clarifications:
• Uses clear pacing.
• Presents logically organized information.
Connection to Lesson:
Students present their final lunar base designs.

### ITEEA Standard: STL 17

Full Standard: Understand information and communication technologies.
Benchmark Clarifications:
• Uses digital tools.
• Communicates visually.
Connection to Lesson:
Students develop slides, diagrams, and media for their presentation.