
SPACE SCIENCE KIT

“The Returner” — Lunar Return Vehicle — Lesson 06

Enhanced Lesson Plan | Grades 6–8 | Science, Technology, Engineering

LESSON OVERVIEW

Lesson Title	"The Returner" — Design, Build & Program a Lunar Return Vehicle Simulation
Subject Area	Science, Technology, Engineering (STEM)
Grade Level	Grades 6–8 (Adaptable for 5 and 9)
Duration	3 Class Periods × 45 Minutes (135 minutes total)
Key Themes	Lunar Ascent, Return Trajectory, Re-entry Physics, Telemetry, Multi-Phase Programming
Framework	5E Instructional Model (Engage, Explore, Explain, Elaborate, Evaluate)
Builds On	Lesson 05 — Lunar Exploration Vehicle (full confidence with dual motors, Sonar:bit, multi-task programs, and mission sequences)

LESSON CONTEXT

What makes Lesson 06 distinct from previous lessons?

- Lessons 01–05 focused on getting to the Moon and operating on its surface. Lesson 06 completes the full mission arc: getting back to Earth.
- The Lunar Return Vehicle (LRV) — nicknamed "The Returner" — models the ascent stage launch from the Moon, orbital rendezvous, trans-Earth injection, and atmospheric re-entry.
- The coding focus shifts from navigation and obstacle avoidance to a multi-phase return sequence: ascent burn → orbit → trans-Earth injection → re-entry simulation → splashdown. Students use motor speed, timing, and Sonar:bit-triggered events to simulate each phase.
- A new concept — simulated telemetry — is introduced: the micro:bit LED displays mission status codes at each phase, mirroring how real spacecraft broadcast data to mission control throughout the return journey.

SMART LEARNING OBJECTIVES

By the end of this lesson, students will be able to:

#	Objective	Domain
1	Design and build a structurally accurate lunar return vehicle model using building blocks that visually represents the ascent stage, crew capsule, and a simulated heat shield or parachute system for re-entry.	Design / Engineering
2	Write and upload a MakeCode program that simulates a complete 5-phase return sequence: lunar ascent burn → orbit → trans-Earth injection → re-entry deceleration → splashdown — using motor speed changes, LED telemetry codes, and a Sonar:bit-triggered event.	Programming / Technology
3	Explain the key phases of a lunar return mission, the engineering challenges of each phase (especially re-entry heating and trajectory precision), and connect at least two physics principles (Newton's 3rd Law, kinetic energy, atmospheric drag) to their vehicle design and code.	Science / Knowledge
4	Collaborate effectively in a team of 3–4 across all three days, fulfilling a defined role, contributing to all phases, and jointly presenting a mission simulation with justified engineering and programming decisions.	Collaboration / Communication

SUCCESS CRITERIA (I CAN STATEMENTS)

Students will demonstrate success when they can:

- I can sketch and label the key components of my lunar return vehicle (ascent stage, crew capsule, heat shield/parachute) before building.
- I can build a stable return vehicle model that represents the ascent stage with a motor mechanism and a re-entry module.
- I can write a MakeCode program with 5 distinct return phases using motor speed changes, LED telemetry codes, and a Sonar:bit trigger.
- I can explain each of the 5 return phases and describe the physics force or engineering challenge most critical at that phase.
- I can run 3 timed return simulation trials, record results on a Testing Log, and make at least one targeted improvement between runs.
- I can present my vehicle's design, return sequence code, and physics connections clearly with a live mission simulation.
- I can give specific, constructive feedback to another team using the "2 Stars & 1 Wish" format.

KEY VOCABULARY

Introduce these terms using a word wall, glossary cards, or a Quizlet Live activity at the start of Day 1:

Term	Definition	Real-World Connection
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Ascent Stage	The upper portion of the lunar lander that launches off the Moon's surface carrying the crew back to lunar orbit.	Apollo LM ascent stage fired its engine from the lunar surface and docked with the Command Module in orbit
Trans-Earth Injection (TEI)	A rocket engine burn performed in lunar orbit that propels the spacecraft onto a trajectory toward Earth.	Apollo crews performed TEI after leaving lunar orbit — no turning back once fired
Atmospheric Re-entry	The phase when a returning spacecraft enters Earth's atmosphere at high speed, generating extreme heat through friction and drag.	Apollo capsule reached ~2,760°C during re-entry — protected by an ablative heat shield
Heat Shield	A protective layer on the spacecraft's base that absorbs and dissipates the enormous heat generated during atmospheric re-entry.	Apollo's heat shield was made of ablative material that burned away to carry heat off the capsule
Splashdown	The final phase of a crewed return mission, where the crew capsule lands in the ocean after parachute deployment.	All Apollo missions splashed down in the Pacific Ocean; Artemis Orion also targets ocean recovery
Telemetry	Real-time data transmitted from a spacecraft to mission control, including speed, temperature, position, and system status.	Mission control monitors thousands of telemetry channels during every crewed mission
Re-entry Corridor	The precise narrow band of angle at which a spacecraft must enter the atmosphere — too steep burns up, too shallow skips off.	Apollo had a re-entry corridor only about 5 degrees wide — a razor-thin margin for error
Orbital Rendezvous	The precise maneuver where two spacecraft meet in orbit at the same position and velocity to dock.	Apollo LM ascent stage had to rendezvous with the Command Module in lunar orbit for crew transfer

MATERIALS & RESOURCES

Category	Item	Purpose
Hardware	micro:bit v2 (1 per team)	Main programmable controller for the full return sequence
Hardware	Nezha Breakout Board V2	Connects micro:bit to the ascent motor and Sonar:bit sensor
Hardware	PlanetX Smart Motor	Simulates the ascent engine burn and return trajectory phases through speed changes
Hardware	PlanetX Sonar:bit (ultrasonic sensor)	Triggers the splashdown event when the vehicle detects the simulated ocean surface

Hardware	USB Cables (1 per team)	Flash programs from computer to micro:bit
Construction	Elecbreaks Bricks Pack (LEGO-compatible blocks)	Physical model: ascent stage, crew capsule, heat shield, parachute representation
Software	MakeCode (makecode.microbit.org)	Block-based / JavaScript IDE with PlanetX extension
Classroom	Projector / Interactive Whiteboard	Teacher demonstrations and team code sharing
Classroom	Simulated Splashdown Surface (soft pad or tray of water-coloured paper)	Represents the ocean surface for the Sonar:bit-triggered splashdown event
Classroom	Return Vehicle Design Brief & Testing Log Sheets	Structured planning and 5-phase simulation recording
Optional	Return Trajectory Diagram (printed)	Visual reference for all 5 mission phases with real timing and speed data
Optional	AI Tool (e.g., Claude, ChatGPT)	Vocabulary support, re-entry physics research, debugging guidance

LESSON STRUCTURE — 5E MODEL

Total time: 3 × 45-minute class periods. Day 1: Design & Build | Day 2: Programming & Functionality | Day 3: Testing, Iteration & Presentation.

DAY 1: DESIGN & BUILD

ENGAGE — Introduce Context, Spark Interest & Activate Prior Knowledge (15 min)

Time	Activity	Teacher Actions	Student Actions
0–5 min	Entry Task	Display prompt: "A spacecraft returning from the Moon must decelerate from 40,000 km/h to 0 at splashdown — using only atmospheric drag and parachutes in the final phase. What engineering problems does this create?" Students respond on sticky notes.	"Write or sketch a response; post on the class board. Revisit these ideas during the Explain phase.
5–12 min	Video Inspiration	Play a 3–4 min clip of an Apollo LM ascent stage launch from the Moon's surface, followed by footage of an Apollo or Artemis Orion capsule re-entering Earth's atmosphere (glowing plasma trail) and splashdown. Pause and ask: "What forces are	Watch and note 2 observations: one about the ascent launch and one about the re-entry or splashdown. Discuss with a partner.

acting on the vehicle at each moment? Why does it glow during re-entry?"

12–
15
min

Whole-Class
Brainstorm

Facilitate discussion: What are the key components of a lunar return vehicle? What are the phases of the return journey? Build a class timeline on the board: Ascent → Orbital Rendezvous → TEI → Re-entry → Splashdown. Ask: "Which phase do you think is most dangerous — and why?"

Contribute to the timeline; record all 5 phases with a brief note on the key challenge at each phase in their notebooks.

EXPLORE — Return Vehicle Construction (20 min)

Time	Activity	Teacher Actions	Student Actions
0–5 min	Design Brief	Distribute Design Brief sheets. Prompt teams: "Your return vehicle must represent: (1) an ascent stage with a motor mechanism, (2) a crew capsule on top, (3) a heat shield representation on the base (e.g., a wide flat plate of blocks), (4) an optional parachute feature. The Sonar:bit should face downward to detect the splashdown surface. Sketch first — then build."	Sketch and label the return vehicle design. Builder and Coder agree on structure and Sonar:bit orientation before picking up any blocks.
5–20 min	Vehicle Construction	Circulate with guiding questions: "Does your heat shield base look wide enough to simulate the real capsule's blunt-body re-entry shape?" "Is your Sonar:bit aimed straight down and unobstructed?" "Is the motor secure and will it represent the ascent engine burn?" Encourage design accuracy and creative representation of re-entry features.	Construct the return vehicle. Builder leads; Coder plans the 5-phase programming approach; Recorder documents every design decision; Presenter prepares to explain the rationale for key choices.

EXPLAIN — Return Vehicle Systems, Phases & Physics (10 min)

Time	Activity	Description
0–5 min	Key Components & Design Comparison	Lead a brief gallery walk or projected share: each team highlights one design choice. Then introduce

the key components of a real lunar return vehicle: ascent stage engine + propellant, crew capsule (life support, navigation), heat shield (ablative material), parachute system (drogue + main chutes), and recovery beacon. Students annotate a printed return vehicle diagram.

5–10 min Return Mission Phases & Physics

Walk through the 5 return phases and the critical physics at each: (1) Lunar Ascent — thrust vs. Moon's gravity (1/6th of Earth's), reaching orbit. (2) Orbital Rendezvous — precision velocity matching to dock with the return capsule. (3) Trans-Earth Injection (TEI) — a 2–3 minute engine burn that changes trajectory from lunar orbit to Earth approach. (4) Re-entry — kinetic energy converts to heat via atmospheric friction; the re-entry corridor is only $\sim 5^\circ$ wide. (5) Splashdown — parachutes deploy, capsule decelerates from 200 km/h to ~ 30 km/h at water impact. Ask: "Which phase requires the most precise engineering — and why?"

Classroom Management Tip — Day 1 Transitions

- Assign team roles before Day 1: Builder, Coder, Recorder, Presenter.
- Use a 2-minute warning timer before each phase transition.
- At the end of Day 1, photograph each vehicle and upload to a shared class folder before packing away.
- Prepare the simulated splashdown surface (soft pad or blue-paper "ocean") before Day 3.

DAY 2: PROGRAMMING & FUNCTIONALITY

ENGAGE — Review, Connect & Coding Setup (10 min)

Time	Activity	Teacher Actions	Student Actions
0–5 min	Recap Quiz	Show 3 quick questions: (1) Name the 5 return mission phases in order. (2) What is trans-Earth injection? (3) Why is the re-entry corridor so narrow — what happens if it is too steep or too shallow? Teams confer and answer on mini whiteboards.	Discuss as a team; hold up whiteboard answers on teacher signal. Correct misconceptions before coding begins.
5–10 min	MakeCode Setup & Demo	Demonstrate: connecting the motor and Sonar:bit (facing downward) to the Nezha board. Show how to display a	Connect hardware; open MakeCode with PlanetX extension loaded. Coder confirms: (1) motor runs at a

text message on the LED (e.g., "TEI"). Demonstrate a motor speed block. Explain the 5-phase scaffold structure before students begin coding.

test speed, (2) Sonar:bit reads a distance and it displays on the LED — before beginning the return sequence program.

EXPLORE — Code the Return Sequence & Telemetry (25 min)

Time	Activity	Teacher Actions	Student Actions
0–15 min	5-Phase Return Sequence Program	<p>Display scaffold on board: on button A pressed → Phase 1 (Ascent): motor high speed 3s + LED "ASC" → Phase 2 (Orbit): motor medium speed 2s + LED "ORB" → Phase 3 (TEI): motor max speed 2s + LED "TEI" → Phase 4 (Re-entry): motor decelerates (high → medium → slow over 4s) + LED "REN" → Phase 5 (Splashdown): forever loop: read Sonar:bit → IF distance < 5 cm THEN stop motor + LED "SPL" + display celebration icon. Circulate and support.</p>	<p>Coder writes the full 5-phase return sequence; Builder monitors hardware connections; Recorder logs every programming decision and its real-world justification.</p>
15–25 min	Telemetry Simulation & Optimisation	<p>Prompt advanced teams: "Can you add a simulated telemetry broadcast during re-entry: every 1 second during Phase 4, display the current motor speed on the LED as if transmitting data to Mission Control?" "Can you add a second deceleration threshold: ultra-slow motor from 8 cm to 5 cm before splashdown?" "Could you use the micro:bit radio to have a Mission Control micro:bit confirm receipt of each phase change?" Guide beginners to focus on reliable 5-phase execution first.</p>	<p>Test the return sequence (hold vehicle above the splashdown surface; lower during Phase 5 to test sensor). Adjust motor speeds, phase durations, and Sonar:bit threshold. Coder and Builder collaborate; Recorder notes every change and its effect.</p>

EXPLAIN — Code Sharing, Telemetry & Troubleshooting (10 min)

Time	Activity	Description
0–5 min	Code Showcase & Telemetry Discussion	Each team displays their MakeCode project for 90 seconds. The Coder explains: (1) one phase they found hardest to program and why, (2) how their LED telemetry codes connect to real mission data

transmission, (3) one parameter they tuned and its effect. Teacher connects to real telemetry: "Apollo's onboard computer transmitted data 50 times per second to mission control during re-entry — your LED display is a simplified version of that."

5–10
min

Troubleshooting Circle
& Physics
Connections

Build a shared "Bug Board" and "Physics Board" on the whiteboard. Document: common bugs (motor not stopping at splashdown, LED not changing between phases) and their solutions. Also add a "Physics Board": which phase connects to Newton's 3rd Law? Which to kinetic energy? Which to atmospheric drag? This connects code to science explicitly.

Guided Inquiry Prompts for Teacher Use — Day 2

- "Your re-entry phase motor goes straight from high to stop — how would you add a gradual deceleration to make it more realistic?"
- "Apollo re-entered at 40,000 km/h. How does that relate to the concept of kinetic energy — and why does so much of it become heat?"
- "Your Sonar:bit triggers splashdown at 5 cm. If you lower it to 3 cm, what real-world concept does that simulate? What are the risks?"
- "How would you program a Mission Control radio confirmation: the LEV micro:bit sends a signal at each phase change, and a second micro:bit acknowledges it?"

DAY 3: TESTING, ITERATION & PRESENTATION

ELABORATE — Return Simulation: Test & Refine (20 min)

Time	Activity	Description
0–15 min	Full Return Simulation — 3 Timed Runs	Teams run their complete 5-phase return sequence 3 times. After each run, complete the Testing Log: Did all 5 phases execute in order? Did LED codes display correctly at each phase? Did the re-entry phase show deceleration? Did the Sonar:bit trigger the splashdown stop at the correct height? Make one specific targeted improvement between each run.
15– 20 min	Advanced Enhancements (Stretch)	Teams that complete 3 successful full simulations choose one enhancement: (A) Add a graduated re-entry: motor speed decreases in 3 steps during Phase 4 (high → medium → low → Sonar:bit stop). (B) Program a telemetry broadcast: during Phase 4 re-entry, display the current Sonar:bit reading every second on the LED, simulating real-time data transmission. (C) Build and add a physical parachute representation (block fins or cardboard) that deploys (moves or unfolds) when the splashdown phase

begins. (D) Use micro:bit radio to implement a Mission Control radio link that confirms each phase change with an acknowledgement LED on a second micro:bit.

Testing Protocol for Teams

- Run 1: Phase sequence check — do all 5 phases execute in order with correct LED codes? Record: Pass / Partial / Fail per phase.
- Run 2: Re-entry deceleration check — does Phase 4 show a motor speed change (not just a single speed)? Record the speed pattern observed.
- Run 3: Full simulation — 5-phase sequence + telemetry LEDs + Sonar:bit splashdown trigger. Evaluate: Meets / Approaching / Not Yet.
- After 3 runs: implement the single most impactful improvement before the final presentation.

EVALUATE — Presentations, Peer Feedback & Reflection (25 min)

Phase	Time	Description
Return Vehicle Presentation & Demo	4–5 min / team	Presenter explains: (1) design choices — how the model represents the ascent stage, crew capsule, heat shield, and any re-entry/parachute features, (2) programming logic — what each of the 5 phases does, how the LED telemetry works, and which parameter tuning made the biggest difference, (3) physics connection — which forces and principles are demonstrated at each mission phase. Live 5-phase return simulation runs during the presentation.
Peer Feedback	2 min / team	Audience completes a "2 Stars & 1 Wish" card per team: 2 specific strengths + 1 targeted, constructive suggestion. Cards are given to presenting teams at the end of the session.
Series Wrap-Up Reflection	5 min	Whole-class discussion: "Lessons 01–06 covered the full mission arc from launch to return. Which lesson's engineering challenge was hardest — and why?" "What does simulating all 6 lessons teach you about how complex a real space mission is?" "If you could add one more lesson to this series, what would it be?" Celebrate the full series completion.

DIFFERENTIATION STRATEGIES

Learner Group	Strategy	Concrete Example
Beginning / SEN	Scaffolded tasks with visual supports	Pre-built starter vehicle chassis to modify; illustrated step-by-step

		coding guide; visual flowchart of the 5-phase return sequence with LED codes labelled
Beginning / SEN	Reduced scope	Focus on a 3-phase sequence (Ascent, Re-entry, Splashdown) rather than all 5; use sentence starters for reflection and presentation; annotate printed code instead of writing from scratch
ELL Students	Language support	Bilingual vocabulary card for all 8 key terms; permit labelled diagrams instead of written explanations; pair with a bilingual peer where possible
ELL Students	Comprehensible input	Physical demonstrations alongside verbal instructions; phase timeline diagram with images for each stage; hardware setup cards with annotated connection images
Average Learners	Core task completion	Complete the full 5-phase return sequence with LED telemetry codes and Sonar:bit splashdown trigger; explain 2 physics principles and 3 mission phases in the presentation
Advanced Learners	Open-ended extensions	Add graduated re-entry deceleration; program telemetry data broadcast during re-entry; build a parachute feature; reference a real return mission with specific data in the presentation
Gifted / High Ability	Challenge by choice	Design micro:bit radio Mission Control link with phase acknowledgements; calculate the kinetic energy of the Apollo capsule at re-entry entry ($KE = \frac{1}{2}mv^2$) and compare to a falling object; explore JavaScript view in MakeCode

ASSESSMENT — FORMATIVE & SUMMATIVE

Formative Assessment (Ongoing — During the Lesson)

Method	When	What to Look For
Sticky Note Entry Task	Day 1, 0–5 min	Surface understanding of re-entry physics; identify misconceptions about drag, heat, and deceleration to address in Explain
Return Mission Timeline	Day 1, 12–15 min	Check understanding and correct sequencing of all 5 return phases before building begins

Design Brief Review	Day 1, Build phase	Assess whether sketches include ascent motor, heat shield representation, downward Sonar:bit, and a described crew capsule
Mini Whiteboard Recap Quiz	Day 2, 0–5 min	Verify retention of all 5 return phases, TEI definition, and re-entry corridor concept from Day 1
Hardware Confirmation Check	Day 2, Setup phase	Confirm motor runs and Sonar:bit reads distance before the 5-phase program begins
Phase-by-Phase Code Review	Day 2, Explore phase	Check that all 5 phases are coded, LED codes are present, and re-entry shows a speed change rather than a single speed
Code Sharing Spot-Check	Day 2, Explain phase	Verify Sonar:bit trigger logic is correct and telemetry LED codes match their mission phase
3-Run Testing Log	Day 3, Elaborate phase	Assess iterative thinking — did teams identify specific failures per phase and make targeted improvements between runs?
Exit Ticket (3-2-1)	End of Day 3	3 physics principles or mission phases learned; 2 design/code decisions made; 1 connection to a real return mission (Apollo, Artemis, Chang'e)

Summative Assessment (End of Lesson)

Criterion	Beginning (1)	Developing (2)	Achieving (3)	Exceeding (4)
Design & Build	Vehicle is incomplete or does not represent key return components	Vehicle is recognisable but missing heat shield, Sonar:bit orientation is incorrect, or crew capsule is absent	Vehicle clearly shows ascent stage, crew capsule, heat shield base, and downward-facing Sonar:bit; is structurally stable	Vehicle is polished and detailed; includes creative parachute/fin features; design shows clear understanding of blunt-body re-entry shape and stage representation
Programming	Code does not run or phases are absent	Code runs but fewer than 3 phases execute or LED codes are missing/incorrect	All 5 phases execute in order with correct LED telemetry codes; Sonar:bit triggers a clean	Code includes graduated re-entry deceleration, telemetry data broadcast, parachute feature trigger, or Mission

Science Knowledge	Cannot name return phases or explain physics	Names 1–2 phases or forces with prompting	splashdown stop Explains all 5 return phases and 2 physics principles (e.g., Newton’s 3rd Law, kinetic energy, drag) independently	Control radio link Connects design and code to real mission data; references Apollo re-entry speed, heat shield temperatures, or re-entry corridor angle with specific accuracy
Collaboration	Does not contribute meaningfully across all 3 days	Contributes minimally; needs frequent prompting to stay on task across days	Contributes consistently across all 3 days; all team members participate in design, coding, testing, and presentation	Leads or mentors peers; documents decisions systematically; adapts role as needed; resolves disagreements constructively
Presentation	Presentation is unclear; live 5-phase demo does not complete	Presents some phases clearly; limited explanation of physics connections or telemetry logic	Clearly presents all 5 return phases, telemetry code logic, and physics connections; live demo completes successfully	Presents with confidence and technical vocabulary; explains parameter choices; responds well to questions; makes strong connections to real return missions

TECHNOLOGY & AI INTEGRATION

Tool / Platform	How to Use in This Lesson
MakeCode (makecode.microbit.org)	Primary coding environment; block view for beginners, JavaScript view for advanced; use the LED display blocks extensively for telemetry simulation; use the simulator to preview phase logic before flashing
micro:bit v2 + Nezha Board + Motor + Sonar:bit	Full physical computing stack; Sonar:bit faces downward to trigger splashdown; motor speed changes across 5 phases simulate the full return journey energy profile
micro:bit Radio (Advanced)	Mission Control simulation: one micro:bit acts as Mission Control and displays received telemetry phase

AI Chatbot (Claude / ChatGPT)	codes; the vehicle micro:bit sends a radio signal at each phase transition Students can ask: "What temperature does an Apollo capsule reach during re-entry?" or "Why isn't my Phase 4 motor decelerating smoothly?" Teach responsible AI use: verify facts with NASA sources, test code yourself
NASA Apollo & Artemis Return Resources	NASA's Apollo 11 re-entry data and Artemis Orion splashdown pages provide real physics data for comparison — e.g., Orion Artemis I splashdown in December 2022
QR Code Resource Stations	Link to MakeCode starter project, 5-phase return diagram, vocabulary glossary, and hardware setup guide for independent and differentiated pacing
Padlet / Google Slides Portfolio	Digital portfolio for vehicle photos, testing log results, LED telemetry screenshots; allows structured peer comments across teams

AI Responsible Use Guidance for Students

- Use AI to understand vocabulary, research re-entry physics, or debug code — always verify facts from NASA or ESA official sources.
- Test any AI-suggested code yourself and explain what each block does before presenting it to the class.
- When referencing re-entry physics data (temperatures, speeds, angles), cross-check AI answers with NASA's Apollo Mission Reports or Artemis mission pages.
- Do not copy AI-written explanations — use them as a starting point and restate in your own words with your own examples.

REAL-WORLD CONNECTIONS

Connection	Discussion Prompt
Apollo 11 Return — Re-entry & Splashdown (1969)	"Apollo 11 re-entered at ~40,000 km/h and reached ~2,760°C on the heat shield. The crew felt up to 6.5 times their body weight during deceleration. How does your Phase 4 re-entry motor deceleration simulate this experience — and what forces does it represent?"
Artemis Orion Capsule Splashdown (2022)	"NASA's Artemis I Orion capsule splashed down in the Pacific Ocean in December 2022 after returning from the Moon. It used the same blunt-body heat shield concept as Apollo. How does your heat shield block design reflect this engineering choice?"
China Chang'e-5 Sample Return (2020)	"China's Chang'e-5 mission returned 1.7 kg of lunar soil to Earth in December 2020 — the first lunar samples returned since 1976. It had no crew, but the re-entry and parachute phases were identical in principle to crewed missions. How does removing a crew change

	the engineering requirements — and what stays the same?"
Re-entry Corridor Physics	"The re-entry corridor is only about 5 degrees wide. Too steep and the capsule burns up; too shallow and it bounces off the atmosphere like a stone skipping on water. How does this precision challenge connect to your Sonar:bit threshold — the narrow range that must trigger splashdown at just the right height?"
SpaceX Crew Dragon Return	"SpaceX's Crew Dragon uses the same atmospheric re-entry and splashdown method as Apollo, but with a modern heat shield and updated parachute system. How does comparing Apollo (1969) to Crew Dragon (2020) show the evolution of return vehicle engineering?"
Future Lunar South Pole Returns	"Artemis III will land near the Moon's south pole — a location with much more rugged terrain than Apollo sites. How would the terrain at launch affect the ascent stage design — and how does that connect to your motor and structure choices?"

EXTENSION ACTIVITIES

Activity	Description	Suggested For
Lunar Return Mission Research	Research 3 lunar return missions (e.g., Apollo 11, Chang'e-5, Artemis I). Compare their ascent vehicle design, re-entry heat shield approach, parachute systems, and splashdown or landing methods in a 1-page illustrated comparison.	Average & Advanced
Graduated Re-entry Deceleration Challenge	Program a 4-step re-entry deceleration: high → medium → low → ultra-slow → Sonar:bit splashdown stop. Add a second Sonar:bit threshold (10 cm → switch to ultra-slow; 5 cm → stop). Time the full re-entry phase and compare to the Apollo 12-minute powered descent equivalent.	Advanced / Gifted
Telemetry Data Broadcast Simulation	During Phase 4 (re-entry), program the micro:bit to display the Sonar:bit reading every second on the LED, simulating live data transmission to Mission Control. Manually record each reading during a timed run and create a distance-vs-time graph.	Advanced / Gifted
Future Lunar Return Presentation	Create a 3-minute multimedia presentation on NASA's Artemis return plans or SpaceX Starship's proposed direct-entry return concept. Compare to Apollo re-entry and explain 2 engineering improvements made since 1972.	All levels
Mission Control Radio Simulation	Use two micro:bits with radio: the vehicle sends a coded message at each phase change (e.g., "P1", "P2"...) and Mission Control acknowledges it with an LED display.	Gifted

	<p>Simulate a communication blackout during re-entry (no radio for 4 minutes — as in Apollo) by switching off the radio blocks during Phase 4.</p> <p>Research: the Apollo capsule had a mass of approximately 5,900 kg and re-entered at 11,000 m/s. Calculate: $KE = \frac{1}{2}mv^2$. Convert the answer to kWh of energy. Compare this to the energy needed to power your school for a day. Present the calculation and the comparison.</p>	
Re-entry Kinetic Energy Calculation		Gifted

HOMEWORK / FOLLOW-UP TASKS

Task	Instructions	Due
Return Mission Reflection Journal	<p>Write 200–250 words: Which of the 5 return phases was most challenging to program — and how did your team solve it? What real-world physics principle did you connect most clearly to your code? Now that you have simulated the full mission arc (Lessons 01–06), which lesson’s engineering challenge was most surprising — and why?</p>	Next class
Real Return Mission Connection	<p>Find a news article or video about a real spacecraft returning from the Moon or a crewed re-entry published in the last 3 years. Write 3 sentences: (1) what the mission or vehicle was, (2) one similarity to your return vehicle simulation, (3) one major engineering difference between that real mission and your model.</p>	Next class
Extension (Optional)	<p>Calculate the kinetic energy of the Apollo 11 Command Module at re-entry (mass ~5,900 kg, speed ~11,000 m/s). Use $KE = \frac{1}{2}mv^2$. Express your answer in joules and megajoules. Write 2 sentences explaining what happens to this energy during re-entry and why the heat shield is the most critical single component of the return vehicle.</p>	Next class

TEACHER NOTES & TIPS

Before the Lesson

- Review Lesson 05 student portfolios and note any persistent Sonar:bit or motor issues — address at the start of Day 2.
- The 5-phase program is the most complex in the series — pre-load a MakeCode starter scaffold with the phase structure already outlined (phases named, LED blocks in place) to support beginners.
- Test all motor and Sonar:bit connections. Confirm the Sonar:bit reads reliably when facing downward toward the splashdown surface height you plan to use.

- Prepare the simulated splashdown surface: a soft pad, foam sheet, or blue-paper "ocean" at a consistent height below where teams will hold the vehicle.
 - Print the Return Vehicle Design Brief, 5-phase timeline diagram, vocabulary cards, and Testing Logs before Day 1.
 - Bookmark Apollo 11 ascent stage launch footage and Artemis Orion splashdown clips on a dedicated browser tab.
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During the Lesson

- The 5-phase program is the most ambitious coding task in the series — give students the full 25 minutes of Day 2 Explore time and manage transitions strictly.
 - Key coding challenge: Phase 4 (re-entry) must show a motor speed change — not just a single speed. Insist on this as the minimum for "Achieving" level; it is the direct analogue of atmospheric deceleration.
 - The LED telemetry codes ("ASC", "ORB", "TEI", "REN", "SPL") are a visible, assessable representation of mission awareness — check them explicitly during the code sharing.
 - For SEN students, the Recorder role allows full participation; they can document LED codes displayed and motor behaviour observed during each test run.
 - Connect the Apollo 1202 alarm story from Lesson 04 again here: debugging under pressure is part of real mission operations at every phase.
 - Use the final wrap-up reflection to celebrate the full Lessons 01–06 mission arc explicitly — students have simulated an entire lunar mission from launch to return.
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After the Lesson

- Compile the full Lessons 01–06 series portfolio for each team: photos of all 6 builds with brief captions.
 - Consider hosting a "Full Mission Exhibition": display all 6 lesson builds in sequence from Launch Pad (Lesson 01) to Returner (Lesson 06) with student-written mission summaries.
 - Share a compiled class "Mission Operations Manual" document containing all 6 lessons' Bug Boards, Testing Logs, and Troubleshooting Guides.
 - Use Lesson 06 reflection journals to plan any future units on space physics, robotics, or advanced coding.
 - Celebrate the series completion explicitly — completing a full simulated lunar mission across 6 engineering lessons is a remarkable achievement.
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CURRICULUM STANDARDS ALIGNMENT

Standard Framework	Alignment
NGSS (Next Generation Science Standards)	MS-PS2-1: Newton's Laws (ascent thrust, re-entry drag); MS-PS3-2: Kinetic energy conversion during re-entry; MS-ETS1-1 to 1-4: Engineering Design; HS-ETS1-2: Complex real-world problem-solving
CSTA (Computer Science)	Level 2 (Grades 6–8): Multi-phase algorithms, LED output for telemetry simulation, proximity sensor triggers, parameter tuning, and iterative debugging across a 5-phase program
ISTE Standards (Students)	Empowered Learner, Innovative Designer, Computational Thinker, Creative Communicator, Global Collaborator
Common Core (Supporting)	KE calculation (algebra); phase timing ratios; data recording across 3 timed runs; structured oral presentation with technical vocabulary and physics evidence
21st Century Skills (4Cs)	Critical Thinking (5-phase debugging), Creativity (return vehicle design), Collaboration (team roles across 3 days + full series), Communication (mission simulation presentations with physics connections)
Series Completion	Lesson 06 is the final lesson in the Space Science Kit Lessons 01–06 series, completing the full mission arc from launch pad to lunar return and splashdown

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