Off the Planet

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This resource was developed as a result of participation in CSIRO's teacher professional learning program, Educator on Board.

<table>
<tr><td>Unit/Lesson Title: Off the Planet Lesson No. 1</td><td>Lesson duration: 1Hr</td><td>Stage: 4
Year: 9</td></tr>
<tr><td>Rationale

ENGAGE / EXPLORE

Living on another planet, or underwater, may be a real possibility in the future. What problems would need to be overcome to enable humans to live in extreme environments? This whole-class lesson is intended to introduce students to unbalanced forces and mass vs. weight in order to solve problems associated with establishing an artificial ecosystem on another planet and / or underwater.</td><td>Syllabus Outcomes

SC4-4WS: Identifies questions and problems that can be tested or researched and makes predictions based on scientific knowledge.

SC4-5WS: Collaboratively and individually produces a plan to investigate questions and problems.</td><td>Syllabus Content

PW1: Change to an object’s motion is caused by unbalanced forces acting on the object. (ACSSU117)
Students:
a. identify changes that take place when particular forces are acting
b. predict the effect of unbalanced forces acting in everyday situations

PW2: The action of forces that act at a distance may be observed and related to everyday situations.
Students:
e. identify that the Earth’s gravity pulls objects towards the centre of the Earth (ACSSU118)
f. describe everyday situations where gravity acts as an unbalanced force
g. distinguish between the terms ‘mass’ and ‘weight’</td></tr>
<tr><td>Prior Knowledge

• Students are able to identify gravity as an unbalanced pulling force and buoyancy as an unbalanced pushing force

• Students will build on their problem solving skills</td><td>Risk Assessment

• Electrical Cords

• Internet Use – Control/Misuse

• Laptops and Tablets used safely (e.g., opened on clean desks)</td><td>Resources

• CSIRO book: Imagining the Future

• Laptop

• Envelopes/cards (Appendix 1) (to be printed off prior to lesson)

• Internet Access

• Tablets (if available)

• YouTube: https://youtu.be/iDj5TxZUAnk</td></tr>
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Learning Outcomes	Time Guide	Content/Learning Experiences
Students will appreciate the importance of science in their daily lives and the role of scientific inquiry in increasing their understanding of the world around them.	5min	**Introduction (Engagement)** Teacher introduces the new unit and the ultimate goal of designing (and possibly building) a model self-sustaining habitat for another planet / underwater. ENGAGE students quickly by asking them, "Did you know that I [resource author] designed, built and lived underwater in the world's first self-sufficient underwater habitat for more than two weeks?" Show students an ABC Behind The News story which features the BioSUB Project: https://youtu.be/iDj5TxZUAnk (alternative reference: CSIRO's Imaging the Future Book, pg. 78.)
	5min	The video shows humans living in space and underwater. Explain to students that Astronauts routinely use underwater habitats to train for future space missions and that there are many parallels to living under the water and living in outer space. The most common two are weightlessness and living in an environment with different air and water pressures. While living in underwater habitats the air / water pressure is higher than normal. While living in space there is almost a complete absence of air pressure or a vacuum.
Students will understand the effect of unbalanced forces on objects.	10min	Both environments have special considerations for those living there. As a whole-class, create a concept map (related to the YouTube video) around the word 'Forces' on the smart board to gather information on students' prior knowledge on the topic and its interconnectedness to gravity, buoyancy, pressure, density, volume and mass vs. weight. Students use each concept once and link with lines or arrows by talking aloud.
Students will identify questions and problems that can be tested or researched and make predictions based on scientific knowledge.	35min	**Body (Exploration/Transformation/Presentation)** 1st EXPLORE activity: Once the concept map has been completed, students are allocated to teams of four and divide themselves into team jobs (Manager, Speaker, Director and Reports coordinator). The Manager from each team is asked to come and collect at random one of 7 envelops from the teacher. Each envelope contains a laboratory challenge that the team will complete during the next double lesson (Appendix 1). The envelopes will also contain example questions and links to suggested experiments. However, this 1st EXPLORE activity will encourage students to design their own experiment or alter the suggested ones in some way. Students need to make a list of resources they need to carry out their experiment and have the team Manager present them to the teacher for final approval.

Students will develop problem solving and team skills.	5min	**Conclusion (Presentation/Reflection)** Bring the lesson to a conclusion by highlighting what was covered and re-capping the aims met today. Briefly explain the next lesson (laboratory) and how the different student teams represent different parts of the concept map they created. Each team will explain their work to the class at the end of the laboratory exercise. Students will be evaluated on their knowledge of all teams work, not just their own. Ask students to start thinking about how they would design a model self-sustaining building / habitat that may be used to support human life on another planet or in an extreme environment (e.g., underwater).

Appendix 1: Envelopes for Student Teams

Envelope No.	Challenge	Example Questions
1: Potato Stabbing	Design an experiment to demonstrate the concept and relationship of **forces and pressure**. For example: http://www.sciencekids.co.nz/experiments/stabapotato.html Create an annotated diagram of your set-up using captions and force arrows to describe the forces acting.	What do you think will happen if you stab a potato with a straw (ends open)? What do you think is going to happen if you hold one end of the straw and stab the potato again? Why was the straw able to penetrate the potato the second time? Why did the air pressure not increase the first time? How does this experiment relate to living underwater / on another planet?
2: Cartesian Diver	Design an experiment to demonstrate the concept and relationship of **buoyant force, volume, water pressure, air pressure.** For example: http://www.stevespanglerscience.com/lab/experiments/five-divers Create an annotated diagram of your set-up using captions and force arrows to describe the forces acting.	Why does the 'diver' float? What are you increasing when you squeeze the bottle? Why does the 'diver' sink? What happens to the volume of air when you let go of the bottle? Are you changing the amount of air you have in the 'diver'? If you are not changing the amount of air then why does the 'diver' sink? How do fish stay buoyant? How does this experiment relate to living underwater / on another planet?
3: Toilet Plungers	Design an experiment to demonstrate the concept and relationship of **air pressure and vacuums.** For example: https://youtu.be/fguD27Q2ijg	What was pushed out of the plungers when you pushed them together? Where was the lower air pressure located? Where was the higher air pressure located? What happened when you tried to pull

	Create an annotated diagram of your set-up using captions and force arrows to describe the forces acting.	apart the two ends of the plungers? What would happen if the air pressures were the same on the inside and the outside of the plungers? What is a vacuum? How does this experiment relate to living underwater / on another planet?
4: Gravity Free Water	Design an experiment to demonstrate the concept and relationship of **gravity, weightless, forces.** For example: https://youtu.be/ah5Rm-1bS3U Create an annotated diagram of your set-up using captions and force arrows to describe the forces acting.	What causes things to fall to the ground when dropped? Why does the water and the cardboard not fall to the ground? If there were air in the glass would the results be the same? Will gravity change on different planets? What effect would this have on the 'mass' and 'weight' of astronauts? How does this experiment relate to living underwater / on another planet?
5: Floating Eggs	Design an experiment to demonstrate the concept and relationship of **buoyancy and density.** For example: https://youtu.be/zszw6uCiQpc Create an annotated diagram of your set-up using captions and force arrows to describe the forces acting.	Which solution did the egg float in? Why did the egg not float in the fresh water? Why did the egg float in the salt water? If you wanted the easiest place to practice floating where it would be? a. pool (freshwater) b. the lake c. the ocean d. the pond What determines whether an object will float or sink? How do big ships (cruise ships, aircraft carriers etc) float? How does this experiment relate to living underwater / on another planet?
6: Density of different metal objects	Design an experiment to demonstrate the concept and relationship of **density of volume**.	How does measuring mass differ from measuring the weight of an object? Density relates what two measurements

	For example: https://youtu.be/uOxERZKjkhE Create an annotated diagram of your set-up using captions and force arrows to describe the forces acting.	to each other? On Earth a package weighs 19.6 newtons. What is the mass of this package on Earth? What would the mass of the package be on Neptune? How does the density of a steel cube compare to the density of a steel nail? Will the density of a material always be same, regardless of its size? Why? How does this experiment relate to living underwater / on another planet?
7: Weight(lessness) underwater	Design an experiment to demonstrate the concept and relationship of **sinking and buoyant force.** For example: http://www.islephysics.net/pt3/experiment.php?topicid=9&exptid=71 Create an annotated diagram of your set-up using captions and force arrows to describe the forces acting.	Draw a free body diagram for an objects hanging from the spring scale before being placed in the water. How do the force of the spring on the object and the weight of the object (the force of the Earth on the object) compare? What does the spring scale measure? Explain why the scale reads differently when the rock is in the water (using the term buoyant force in your answer). How does this experiment relate to living underwater / on another planet?

References:

Ericsurf6. (2010, Apr 27). *Amazing Glass of Water Trick (Tutorial)* [Video]. https://youtu.be/ah5Rm-1bS3U

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RUTGERS. 2015. Submerging an object suspended on a spring scale under water: Observational Experiment. [ONLINE] Available at: http://www.islephysics.net/pt3/experiment.php?topicid=9&exptid=71. [Accessed 10 November 2020].

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Steve Spangler Science. 2019. Five Divers. [ONLINE] Available at: https://www.stevespanglerscience.com/lab/experiments/five-divers/. [Accessed 10 November 2020].

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Unit/Lesson Title: Off the Planet Lesson 2 (Laboratory Lesson)	**Lesson duration:** 2 x 1Hr	**Stage:** 4 **Year:** 9
Rationale EXPLORE / EXPLAIN The aim of this lesson is a hands-on exploration of the problems / questions identified in Lesson No. 1. Students will explore and explain unbalanced forces such as **gravity** and **buoyancy** and become familiar with terms such as **density**, **pressure**, **mass**, **weight** and **volume** and their interconnectedness.	**Syllabus Outcomes** **SC4-7WS:** Processes and analyses data from a first-hand investigation and secondary sources to identify trends, patterns and relationships, and draw conclusions. **SC4-8WS:** Selects and uses appropriate strategies, understanding and skills to produce creative and plausible solutions to identified problems. **SC4-9WS:** Presents science ideas, findings and information to a given audience using appropriate scientific language, text types and representations. **SC4-10PW:** Describes the action of unbalanced forces in everyday situations.	**Syllabus Content** **WS6:** Students conduct investigations by: b. assembling and using appropriate equipment and resources to perform the investigation, including safety equipment e. recording observations and measurements accurately, using appropriate units for physical quantities **WS7.1:** Students process data and information by: a. summarising data from students' own investigations and secondary sources (ACSIS130, ACSIS145) b. using a range of representations to organise data, including graphs, keys, models, diagrams, tables and spreadsheets e. applying simple numerical procedures, e.g. calculating means when processing data and information, as appropriate **WS7.2:** Students analyse data and information by: b. constructing and using a range of representations, including graphs, keys and models to represent and analyse patterns or relationships, including using digital technologies as appropriate (ACSIS129, ACSIS144) d. using scientific understanding to identify

		relationships and draw conclusions based on students' data or secondary sources (ACSIS130, ACSIS145) e. proposing inferences based on presented information and observations
Prior Knowledge • Students can distinguish between the terms mass and weight and are familiar with concepts and terms such as unbalanced forces, gravity, density, pressure buoyancy and volume • Students will develop their communication, laboratory and team skills	**Risk Assessment** • Electrical Cords • Internet Use – Control/Misuse • Laptops and Tablets used safely (e.g., opened on clean desks) • Explain health and safety requirement of laboratory work with students (e.g., safety glasses, gloves, lab coats and handling glassware)	**Resources** • CSIRO Book - Imagining the Future • Laptop • PowerPoint / Excel • Internet Access • Tablets (if available) • Laboratory equipment for student experiments: e.g., graduated cylinder, water container / tank, assorted items made of different and same material, scissors, 2L plastic soft drink bottle, spring scale, bench top scales, rock / weight, eggs, string, salt, glass beakers, cardboard, 2 toilet plungers (clean), potatoes, straws, tomato sauce / soy sauce sachets

Learning Outcomes	Time Guide	Content/Learning Experiences
Students can plan and predict the outcome of an experiment Students can gather, analyse and interpret data. Students can present science ideas, findings and information to a given audience.	5min	**Introduction (Engagement)** To reengage students by linking the lesson to a contemporary issue, show the students a video about the Mars One project: https://youtu.be/n4tgkyUBkbY During the video, the students are asked to take notes to help them with their ELABORATION task in the next lesson.
	40min	**Body (Exploration/Transformation/Presentation)** In this 2nd EXPLORE activity, students reassemble into their teams of four and begin setting up the experiments / activities they designed in Lesson 1. Students complete tasks according to their team jobs, allocated in Lesson 1, further developing their Team Skills and Problem Solving skills.
	25min	Once students have carried out their experiment / activity, they work together to make sense of the data and come up with a way to EXPLAIN it to the rest of the class. Students clean up laboratory before next part of lesson.
	40min	Student teams are given 5min (3min + 2min question time) each to explain their challenge (e.g., the challenge issued, the concepts, the suggested experiment and how they changed it, the questions they were asked and how they answered them). They can present in any manner they choose, but are encouraged to use digital technologies and a range of representations.
	10min	**Conclusion (Presentation/Reflection)** Bring the lesson to a conclusion by highlighting what was covered and re-capping the aims met today. Briefly explain the next lesson in which students will design a self-sustaining habitat that may be used to support human life underwater or on another planet.

References:

Mars One. (2012, Jun 6). *Mars One's human mission to Mars – 2012 introduction film* [Video]. https://youtu.be/n4tgkyUBkbY

<table>
<tr><td>Unit/Lesson Title: Off the Planet Lesson No. 3</td><td>Lesson duration: 1Hr</td><td>Stage: 4
Year: 9</td></tr>
<tr><td>Rationale

ELABORATE / EVALUATE

The aim of this lesson is for students to apply their new knowledge and understanding to the design (and possibly construction) of a model self-sustaining building / habitat that may be used to support human life on another planet or in an extreme environment (e.g., underwater). This activity may be part of a rich task or extension activity in conjunction with Technological and Applied Studies, Students will self-evaluate their learning.</td><td>Syllabus Outcomes

SC4-8WS: Selects and uses appropriate strategies, understanding and skills to produce creative and plausible solutions to identified problems.

SC4-9WS: Presents science ideas, findings and information to a given audience using appropriate scientific language, text types and representations.

SC4-10PW: Describes the action of unbalanced forces in everyday situations.</td><td>Syllabus Content

WS8: Students solve problems by:
d. using cause-and-effect relationships to explain ideas and findings</td></tr>
<tr><td>Prior Knowledge

• Conducting scientific investigations about forces and working scientifically

• Students are able to apply what they have learned in lessons 1 and 2 to everyday and new situations and have discussions using newly acquired language to clarify understanding</td><td>Assessment

• Electrical Cords

• Internet Use – Control/Misuse

• Laptops and Tablets used safely (e.g., opened on clean desks)</td><td>Resources

• CSIRO Book - Imaging the Future

• Laptop

• PowerPoint / Excel

• Internet Access

• Tablets (if available)

• Scoring Guide (Appendix 1)</td></tr>
</table>

Learning Outcomes	Time Guide	Content/Learning Experiences
Students can apply what they have learned to new situations Students can describe the action of unbalanced forces in everyday situations.	20min 15min 10min	**Body (Exploration/Transformation/Presentation)** ELABORATE Pairs of students, from the student teams of 4, work on the design of a self-sustaining habitat that may be used to support human life underwater or on another planet (or both). It could be based on the BioSUB Project (underwater), the Mars One Project (Mars) or a combination of both (underwater on Europa, one of Jupiter's moons). The design must include an annotated diagram of the habitat using captions and force arrows to describe the forces acting. Students are encouraged to use the CSIRO Book Imagining the Future for some ideas (e.g., colonising mars, a ladder to space, Living the dream – underwater) This task will form part of the evaluation in the next part of the lesson. EXTENSION ACTIVITY Students could design a steel underwater habitat, and based on its mass and internal volume, calculate the amount of concrete ballast required to fully submerge it in fresh water. EVALUATE Students are asked to prepare a personal concept map related to Force. **Conclusion (Presentation/Reflection)** Bring the lesson to a conclusion by highlighting what was covered and re-capping the aims met today. Students asked to submit habitat design and concept maps in on way out of classroom.

Appendix 1: Scoring Guide

	4-5	3-4	2-3	1-2
Habitat design	Includes an annotated diagram of the habitat using captions. Force arrows to describe the forces acting are complete and correct.	Includes an annotated diagram of the habitat using captions. Force arrows to describe the forces acting are mostly complete and correct.	Includes an annotated diagram of the habitat using captions. Force arrows to describe the forces acting are partially complete and correct.	Diagram not labeled appropriately.
Concept map	Student demonstrates an in-depth understanding of 'Forces' and its interconnectedness to gravity, buoyancy, pressure, density, volume and mass vs. weight.	Student demonstrates a good understanding of 'Forces' and its interconnectedness to gravity, buoyancy, pressure, density, volume and mass vs. weight.	Student demonstrates a fair understanding of 'Forces' and its interconnectedness to gravity, buoyancy, pressure, density, volume and mass vs. weight.	Student displays a difficulty demonstrating an understanding of'Forces' and struggles to make connections between Forces and gravity, buoyancy, pressure, density, volume and mass vs. weight.