Applicable standards

Next Generation Science Standards (NGSS)

Grade 5 Science and Engineering

Element of the curriculum	Lessons 1	2	3	4	5	6
Matter and Its Interactions						
5-PS1-3. Make observations and measurements to identify materials based on their properties.				✓	✓	
Motion and Stability: Forces and Interactions						
5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down.	✓	✓	✓	✓		
Engineering Design						
3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.	✓	✓	✓	✓	✓	✓
3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.	✓	✓	✓	✓	✓	✓
3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.	✓	✓	✓	✓	✓	

Grade 6-8 Middle School Science and Engineering

Element of the curriculum	Lessons 1	2	3	4	5	6
Matter and Its Interactions						
MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.					✓	✓
Motion and Stability: Forces and Interactions						
MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.	✓	✓	✓			
From Molecules to Organisms: Structures and Processes						
MS-LS1-3. Use arguments supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.						✓
MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and /or release energy as this matter moves through an organism.						✓

Applicable standards

Next Generation Science Standards (NGSS)

Grade 6-8 Middle School Science and Engineering (continued)

Element of the curriculum	Lessons 1	2	3	4	5	6
Engineering Design						
MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.	✓	✓	✓	✓	✓	✓
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.	✓	✓	✓	✓	✓	✓
MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.	✓	✓	✓	✓	✓	

Science and Engineering Practices

Element of the curriculum	Lessons 1	2	3	4	5	6
• Asking questions	✓	✓	✓	✓	✓	✓
• Developing and using models	✓	✓	✓	✓	✓	
• Planning and carrying out investigations	✓	✓	✓	✓	✓	✓
• Analyzing and interpreting data	✓	✓	✓	✓	✓	✓
• Using mathematics		✓	✓	✓		
• Constructing explanations	✓	✓	✓	✓	✓	✓
• Engaging in argument from evidence	✓	✓	✓	✓	✓	✓
• Obtaining, evaluating and communicating information	✓	✓	✓	✓	✓	✓

SCHEME OF WORK

Lesson 1: Submarine shape investigation

Overview

This lesson starts off by establishing the story of the whole unit.
The students will be using the information learned in the unit to design a submarine for exploring the ocean depths.

The context of the lesson is a practical investigation to discover a suitable shape that can dive and rise at a speed safe enough for the scientists inside the submarine. Students develop their understanding of forces, surface area, and fair testing.

Learning outcomes

- Test different shapes to compare how they fall through the water
- Explain how the shape affects the speed of descent
- Design and carry out a fair test
- Explain how differences in gravitational and resistive forces affect descent of an object
- Explain why surface area affects the speed of descent

Resources

Slideshow 1:
Submarine shape investigation

360VR Expedition Guide:
Diving in a submarine

Activity Overview 1:
Submarine shape investigation

Student Sheet 1a:
Submarine shape investigation

Student Sheet 1b:
Submarine shape investigation (differentiated)

Mark Scheme 1:
Submarine shape investigation

360VR Story:
Diving in a submarine

Lesson 2: Submarine buoyancy investigation

Overview

This lesson encourages students to investigate hands-on the property of neutral buoyancy, and to discuss its importance in terms of submarines.

There is a practical investigation to achieve neutral buoyancy for a floating object by adding weight. This session also explores the mathematics of density and buoyancy.

Learning outcomes

- Describe how to make floating objects sink
- Make an object neutrally buoyant through experimentation
- Explain how neutral buoyancy is achieved in terms of forces
- Calculate the volume of a spherical object
- Calculate the weight required to make a floating object neutrally buoyant

Resources

Slideshow 2:
Submarine buoyancy investigation

360VR Expedition Guide:
Diving in a submarine

Activity Overview 2:
Submarine buoyancy investigation

Student Sheet 2a:
Submarine buoyancy investigation

Student Sheet 2b:
Ballast tank diagram

Mark Scheme 2:
Submarine buoyancy investigation

360VR Story:
Diving in a submarine

Lesson 3: Submarine launch investigation

Overview

The submarines used for the XL Catlin Deep Ocean Survey were in the strictest sense submersibles. A distinction is made between true submarines that operate independently and submersibles which require the support of a surface vessel.

In this lesson, students develop an understanding of structural strength and stability. They will then design and build a model crane suitable for lifting and moving a weight. This activity replicates the science involved in launching and recovering a submersible using a surface vessel.

Learning outcomes

- Describe the features of a strong and stable structure
- Describe the purpose of each part of a crane's structure
- Construct a working model of a crane
- Calculate the moments of some given examples
- Explain the importance of launching and raising the submarine from the back of a ship, rather than the side

Resources

Slideshow 3: Submarine launch investigation

Activity Overview 3: Designing a crane

Student Sheet 3a: Designing a crane

Student Sheet 3b: Moments calculations

Student Sheet 3c: Gears and pulleys

Mark Scheme 3: Submarine launch investigation

360 Video:
- Submarine launch
- Submersible recovery

Lesson 4: Submarine pressure investigation

Overview

The operating depth limit for the submersibles used on the XL Catlin Deep Ocean Survey was 1,000 feet. To put this in context, recreational scuba diving has a limit of 130 feet, but the deepest point in the ocean is an astounding 36,070 feet down.

In this lesson, students investigate the effects of pressure increasing with depth, and the implications that this has for submarine design. Get the design wrong and the submarine will implode.

Learning outcomes

- Describe the dangers of exploring at depth
- Explain why pressure increases with depth
- Design and carry out a fair test to investigate the effects of increasing depth
- Calculate the amount of pressure caused at different depths
- Explain, in terms of forces, why submarines have a safe limit to which they can dive

Resources

Slideshow 4: Submarine pressure investigation

Activity Overview 4a: Under pressure

Activity Overview 4b: Submarine pressure investigation

Student Sheet 4a: Submarine pressure investigation

Student Sheet 4b: Pressure calculations

Student Sheet 4c: Cartesian diver

Mark Scheme 4: Submarine pressure investigation

Video:
- Under Pressure
- Submarine Engineer

Lesson 5: Submarine materials investigation

Overview

Submarines have to operate in difficult environments. First, they need to operate under pressure. Second, they have to cope with the corrosive nature of seawater. Different parts of the submarine will need different materials. There is no point building a submarine for scientific operation out of solid metal.

In this lesson, students will start by reflecting on historical submarine designs and some were not very successful. They will then debate materials choices for building a submarine. A practical investigation looks at how to protect the submarine from rusting.

Learning outcomes

- Describe why several different materials are needed to build a submarine
- Carry out a fair investigation into the effects of salt and water on rusting
- Explain why different conditions cause different amounts of rusting
- Make justified choices for the materials used to build a submarine
- Explain oxidation reactions with balanced equations

Resources

Slideshow 5:
Submarine materials investigation

Activity Overview 5:
Submarine 'rusting' investigation

Student Sheet 5a:
Submarine 'rusting' investigation

Student Sheet 5b:
Materials cards

Student Sheet 5c:
Submarine materials choices

Student Sheet 5d:
Submarine 'rusting' predictions

Mark Scheme 5:
Submarine launch investigation

Lesson 6: Submarine life support investigation

Overview

Researching using submarines means that the scientists are working in an enclosed space deep underwater for hours at a time. This lesson investigates the life support systems needed to keep scientists and explorers alive.

Students will conduct an investigation into how limewater can reduce the amount of carbon dioxide in an atmosphere. Students will then design the life support systems needed for a submarine. The lesson concludes with students compiling all their research from the unit to create a submarine design presentation.

Learning outcomes

- Describe the dangers to explorers in the deep ocean
- Conduct an investigation into respiration
- Describe how respiration occurs and its importance
- Balance the respiration equation
- Explain how submarines are built and engineered to sustain life

Resources

Slideshow 6:
Submarine life support investigation

Activity Overview 6:
Respiration investigation

Student Sheet 6a:
Respiration investigation

Student Sheet 6b:
Life support design

Student Sheet 6c:
Submarine presentation

Mark Scheme 6:
Submarine life support investigation

360 Video:
Exploring the deep ocean

Gallery:
- Deep sea creatures
- Life around the vent

Diagram:
Deep ocean poster