Applicable standards
National Curriculum for England Key Stage 2

KS2 Science

Element of the Science Programme of Study	Lessons 1	2	3	4	5	6
Properties and changes of materials						
• Compare and group together everyday materials based on their properties				✓	✓	✓
• Give reasons, based on evidence for the uses of everyday materials				✓	✓	✓
Forces						
• Explain that unsupported objects fall towards the Earth because of the force of gravity			✓			
• Identify the effects of air resistance, water resistance and friction			✓			
• Recognise some mechanisms including levers, pulleys and gears					✓	✓
Living things and their habitats						
• Identify and name a variety of living things	✓	✓				
• Recognise that environments can change	✓	✓				
Working scientifically						
• Ask relevant questions and use different types of scientific enquiry	✓	✓	✓			
• Making systematic and careful observations	✓	✓	✓			
• Plan different types of scientific enquiries			✓	✓	✓	
• Take measurements with increasing accuracy and precision		✓		✓	✓	✓
• Record data and results		✓	✓			
• Make predictions and plan comparative and fair tests			✓	✓		
• Report and present findings			✓		✓	✓
• Use results to draw simple conclusions and raise further questions			✓	✓	✓	✓

KS2 Geography

Element of the Geography Programme of Study	Lessons 1	2	3	4	5	6
Geography skills and fieldwork						
• Use maps, atlases and globes to locate and describe features	✓	✓				

Applicable standards
Next Generation Science Standards

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.	✓	✓	✓			

Applicable standards
Next Generation Science Standards

Grade 6-8 Middle School Science and Engineering (continued) Element of the curriculum	Lessons 1	2	3	4	5	6
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.						✓
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						
• 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	✓	✓	✓	✓	✓	✓

Lesson 1: How big and how deep is the ocean?

Overview

This lesson sets the scene for the whole Submarine STEM unit. 71% of our blue planet is covered by the ocean, with an average depth of 2.3 miles. The ocean affects people's food, safety, livelihoods, transport and access to resources, yet we know very little about the deep ocean – we have better maps of the moon! This lesson explores the importance of the ocean and introduces students to some of the strange creatures which inhabit the deep sea.

Learning outcomes

- Discuss prior knowledge of the ocean
- Understand the scale of the ocean
- Describe how the ocean affects our lives
- Compare, observe and ask questions about the features of deep-sea creatures
- Review learning and make suggestions for future learning

Resources

Slideshow 1: How big and how deep is the ocean?

Student Sheet 1a: Deep-sea funnies

Student Sheet 1b: What I would like to know

Gallery: Deep-sea creatures

Video: Nekton Mission II: The Indian Ocean

Lesson 2: What lives in the deep sea?

Overview

This lesson explores the depth of the ocean through creating a scale diagram of the different ocean zones and identifying significant points within these zones. Students will consider why deep sea exploration is so challenging for humans and the different issues scientists have to overcome. This lesson allows students to examine submersibles and identify their main differences.

Learning outcomes

- Identify living things, habitats and environments
- Understand the scale and depth of the ocean
- Make accurate measurements
- Explain why ocean exploration is challenging for humans
- Describe how different submersibles make ocean exploration possible
- Identify significant ocean zones

Resources

Slideshow 2: What lives in the deep sea?

Activity Overview 2a: Ocean depths

Student Sheet 2a: Deep-sea funnies

Student Sheet 2b: Points of interest

Student Sheet 2c: Ocean zones

Gallery: Deep ocean poster

360 Gallery: Submarine science

Video: Mission Director

Subject Update: How to: Quick start to 360 VR in the classroom

Subject Update: How to: Four ways to use 360 VR in the classroom

Lesson 3: What forces affect submarines?

Overview

The context of the lesson is a practical investigation to discover how shape and surface area affect the speed at which a submersible descends. Students develop their understanding of forces, surface area, and fair testing.

Learning outcomes

- Understand gravity as a force
- Consider how forces affect submersibles
- Investigate how shape affects speed
- Predict and test with accuracy
- Describe how forces affect submersibles

Resources

Slideshow 3: What forces affect submarines?

Activity Overview 3a: Submersible shape investigation

Student Sheet 3a: Shape Investigation

360 Gallery: Diving in a submarine

Subject Update: How to: Quick start to 360 VR in the classroom

Subject Update: How to: Four ways to use 360 VR in the classroom

Lesson 4: How do you choose materials for a submarine?

Overview

This lesson discusses the properties of materials and their use in submersible design. Students will compare a variety of materials for their submersible and justify their choices. An investigation into how salt water affects materials allows pupils to make predictions, write conclusions and conduct a fair test.

Learning outcomes

- Discuss the properties of materials
- Compare and group materials based on their properties
- Give reasons for the uses of materials
- Explain the suitability of materials for certain uses
- Make predictions about how salt-water affects materials

Resources

Slideshow 4: How do you choose materials for a submarine?

Student Sheet 4a: Materials cards

Student Sheet 4b: My submersible materials

Student Sheet 4c: Salt water investigation

360 Video: Submarine launch

Subject Update: How to: Quick start to 360 VR in the classroom

Subject Update: How to: Four ways to use 360 VR in the classroom

Lesson 5: How do you launch a submarine with strong structures?

Overview

Part one of this two-part lesson develops students understanding of strong structures and investigates how cranes work. Students work together to design and construct a crane using a variety of materials. They will adapt and evaluate their structure as they go along and make improvements where necessary. They will also construct a model submersible to launch and recover once their crane is complete.

Learning outcomes

- Describe how machines help people
- Describe and apply the features of a stable structure
- Construct a working model of a crane
- Reflect on learning and plan next steps

Resources

Slideshow 5: How do you launch a submarine with strong structures?

Activity Overview 5a: Designing a crane

Activity Overview 5b: Submersible model

Student Sheet 5a: Designing a crane

360 Video: Submarine launch

Subject Update: How to: Quick start to 360 VR in the classroom

Subject Update: How to: Four ways to use 360 VR in the classroom

Lesson 6: How do you recover a submarine with levers and pulleys?

Overview

Part two sees students develop their understanding of levers and pulleys and relates this to how cranes launch and recover submersibles. Students will continue to develop their crane, this time adding a lever or pulley system which will raise and lower their submarine model. Students will reflect on their build, evaluate the effectiveness of their cranes and make suggestions for improvements. Finally, students will demonstrate their learning by creating a poster which describes and explains how cranes work to launch and recover submersibles, concluding the Submarine STEM unit.

Learning outcomes

- Apply understanding of levers and pulleys
- Construct a working model of a crane using levers and pulleys
- Reflect on learning and suggest improvements
- Explain why cranes are used and how they work

Resources

Slideshow 6: How do you recover a submarine with levers and pulleys?

Activity 6a: Levers and pulleys

Student Sheet 6a: Levers and pulleys

Student Sheet 6b: Poster

360 Video: Submarine launch

Subject Update: How to: Quick start to 360 VR in the classroom

Subject Update: How to: Four ways to use 360 VR in the classroom

How big and how deep is the ocean?

Age 7-11

60 minutes

Curriculum links

- Identify and name a number of living things in the wider environment
- Recognise that environments can change and that this can sometimes pose dangers to living things
- Ask relevant questions and use different types of scientific enquiries to answer them
- Make systematic and careful observations

Resources

Slideshow 1: How big and how deep is the ocean?

Student Sheet 1a: Deep-sea funnies

Student Sheet 1b: What I would like to know

Video: Nekton Mission II: The Indian Ocean

Gallery: Deep-sea creatures

Home learning

Students can visit www.encounteredu.com/discover/videos/nekton-mission-2-the-indian-ocean-full-length and watch the video. Think about what it would be like to experience deep sea exploration. How would it feel? Why is this type of exploration important?

Lesson overview

This lesson sets the scene for the whole deep-sea exploration unit. 71% of our blue planet is covered by ocean, with an average depth of 2.3 miles. At least 97% of our biosphere is in the ocean and it produces half the oxygen we breath. The oceans affect people's food, safety, livelihoods, transport and access to resources, yet we know very little about the deep ocean – we have better maps of the moon! This lesson explores the importance of the ocean and introduces students to some of the strange creatures which inhabit the deep sea.

Lesson steps	Learning outcomes
1. Brief and Assessment for Learning (10mins) Students are introduced to the unit, lesson title and expected outcomes and discuss what they already know about oceans.	• Discuss prior knowledge of oceans
2. Oceans and us (15 mins) Students are guided in discussion about the importance of deep-sea exploration, the scale of oceans and how they affect our lives.	• Understand the scale of oceans • Describe how the oceans affect our lives
3. Deep-sea creatures (10 mins) Students view the Deep-sea creatures gallery, make observations and ask questions about the features of living things.	• Observe and ask questions about the features of Deep-sea creatures
4. Deep-sea funnies game (15 mins) Students demonstrate their learning by playing Deep-sea funnies though comparing size, depth, weird rating and predator level.	• Observe and ask questions about the features of Deep-sea creatures
5. Future learning (10 mins) Students discuss what they are interested in finding out about during this unit and share ideas.	• Review learning and make suggestions for future learning

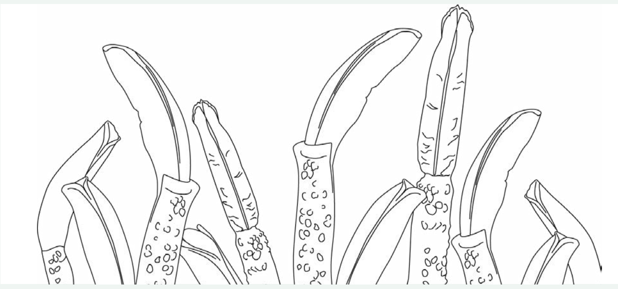
TEACHER GUIDANCE 1 (page 1 of 2)

Step	Guidance	Resources
1 10 mins	Step 1 introduces students to the unit outcomes and lesson objectives and asks students to share what they already know about oceans. · Click on link on slide 1 to play Nekton Mission II: The Indian Ocean video. · Use slides to introduce unit title and learning outcomes. · Ask students to discuss in groups what they know about oceans. · Take brief feedback from students on their prior knowledge.	**Slideshow 1:** Slides 1-4 **Video:** Nekton Mission II: The Indian Ocean
2 15 mins	Step 2 invites students to think about and discuss why deep ocean exploration is important. · Using a globe (and maps) explain that it is sometimes referred to as a blue planet due to 71% of the planet being covered in water. Explain that the ocean produces half the oxygen we breath and captures 16 times the amount of carbon dioxide compared to land. · Explain that we know more about the surface of the moon than we do about deep oceans because deep ocean exploration is so challenging. Ask students why this could be. · Ask students to consider how we rely on the ocean for life on earth and share examples. Use slides to draw out answers focussing on food, safety, livelihoods and transport. · Check learning during discussion to ensure students understand the importance of the oceans.	**Slideshow 1:** Slides 5-8
3 10 mins	Step 3 introduces some of the strange creatures of the deep which are unlike many familiar sea creatures. · Look at and read from Gallery: Deep-sea creatures. Encourage students to comment on their unusual features. Students can work in groups to access media, you can use laptops in the same way as you might view 360° video and photos via a digital projector. Tablets or smartphones that have an inbuilt gyroscope, eg iPads, iPhones and most recent Android devices, will enable students to move the device around and enjoy a virtual reality experience. Smartphones can also be used in conjunction with virtual reality headsets.	**Slideshow 1:** Slide 9 **Gallery:** Deep-sea creatures

Step	Guidance	Resources
4 15 mins	Step 4 involves students playing a game of Deep-sea funnies focussed on deep-sea creatures. · Hand out Student Sheet 1a. To save time, you may wish to cut these out in advance. · Students then play Deep-sea funnies at tables or in small groups. · Cards are divided between children in small groups of up to six. Cards are placed face down on the table in front of each player. · Player 1 lifts the top card and examines the creature and its features then chooses the category which they believe is the strongest. The player to the left then looks at the same category on their top card and whoever has the highest score in that category takes both cards, which go to the bottom of their pile. · At this point players share the information with the rest of the group. The winning player then repeats the process with the top card from their pile towards the player on their left. · The game winner has the most cards at the end of the specified time. · Bring students back together and ask for feedback on the yuckiest, most surprising, funniest thing they learnt.	**Student Sheet 1a:** Deep-sea funnies
5 10 mins	Step 5 asks students to think of questions that they would like to find out about during this unit. · In groups students record questions on mini whiteboards. · Take a question from each group so you have 6-8 and record them somewhere you will be able to reference with the class later in the unit. · Hand out Student Sheet 1b. Students complete this independently. You may wish to differentiate this task through specifying the number or depth of questions.	**Slideshow 1:** Slide 10 **Student Sheet 1b:** What I would like to know
H/L 10 mins	Students can visit www.encounteredu.com/discover/videos/nekton-mission-2-the-indian-ocean-full-length and watch the video. Think about what it would be like to experience deep sea exploration. How would it feel? Why is this type of exploration important?	

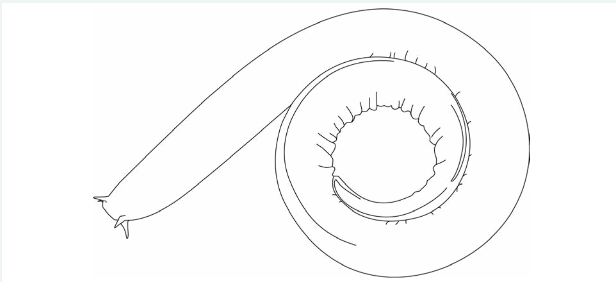
Deep-sea funnies

Giant tube worm



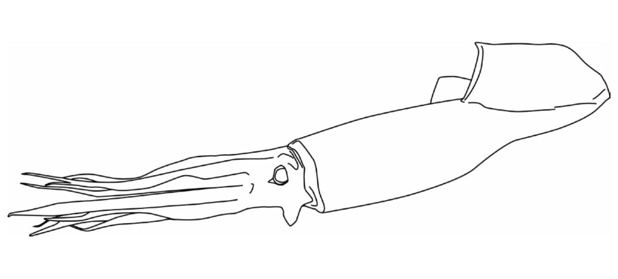
Size	240cm
Max. depth	1800m
Weird rating	8/10: Giant tube worms do not have eyes, mouth, stomach or legs.
Predator level	●○○○
Eats	sugars from bacteria
Eaten by	vent shrimp, yeti crab

Hagfish



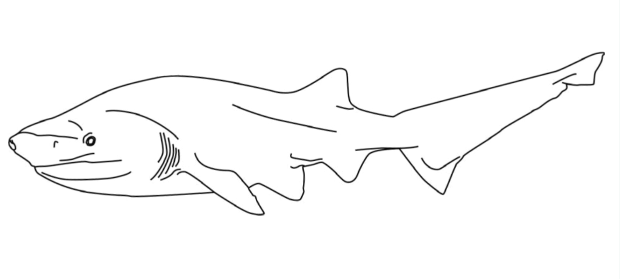
Size	50cm
Max. depth	1800m
Weird rating	8/10: Can turn a large bucket of water into slime in seconds.
Predator level	●○○○
Eats	dead sperm whales and squid
Eaten by	sixgill shark

Giant squid



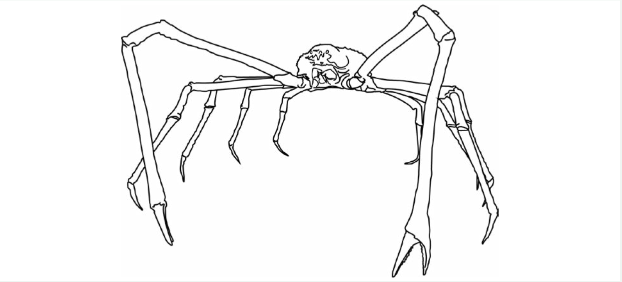
Size	1300cm
Max. depth	1000m
Weird rating	7/10: Their eyes can be 25cm across, the size of a beach ball.
Predator level	●●●○
Eats	ghost shark, six gill shark
Eaten by	sperm whale

Sixgill shark



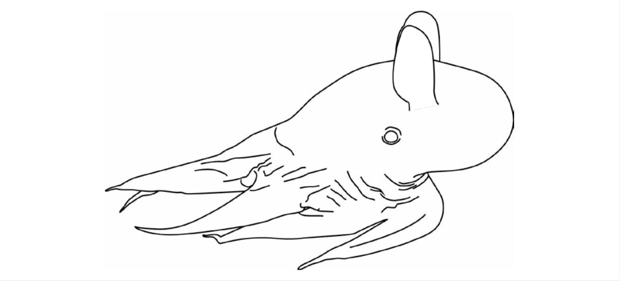
Size	490cm
Max. depth	1850m
Weird rating	5/10: This deepest shark in the world has translucent eyelids.
Predator level	●●●○
Eats	hagfish
Eaten by	orca (not included)

Japanese spider crab



Size	380cm
Max. depth	600m
Weird rating	8/10: Truly frightening, with legs that stretch 1.6 meters.
Predator level	●●○○
Eats	mussels, sea pigs
Eaten by	large octopus (not included)

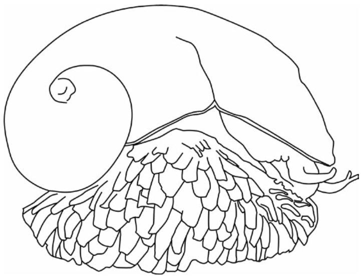
Dumbo octopus



Size	30cm
Max. depth	7000m
Weird rating	6/10: They look like a cartoon elephant.
Predator level	●●○○
Eats	amphipods, isopods
Eaten by	sperm whale

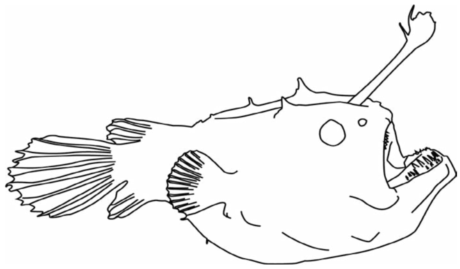
STUDENT SHEET 1a

Scaly foot gastropod



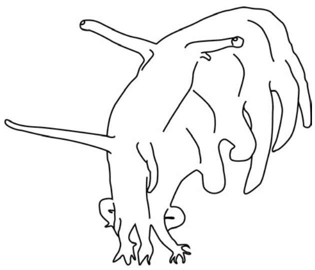
Size	4cm
Max. depth	2800m
Weird rating	6/10: This small snail makes armour plating from iron in the seawater.
Predator level	●○○○
Eats	sugars from bacteria
Eaten by	yeti crab

Angler fish



Size	15cm
Max. depth	4500m
Weird rating	9/10: When mating, the smaller male fuses to the female's body.
Predator level	●●○○
Eats	amphipod, dragon fish
Eaten by	giant squid

Sea pig

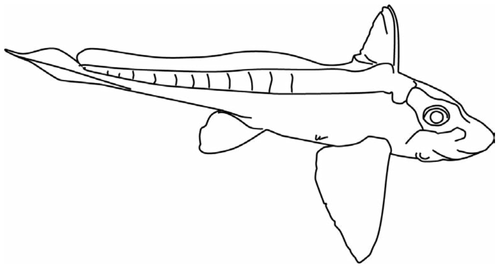


Size	20cm
Max. depth	5000m
Weird rating	5/10: The sea pig is the only sea cucumber to have 'legs'.
Predator level	●○○○
Eats	marine snow
Eaten by	giant isopod, spider crab

Vent bacteria

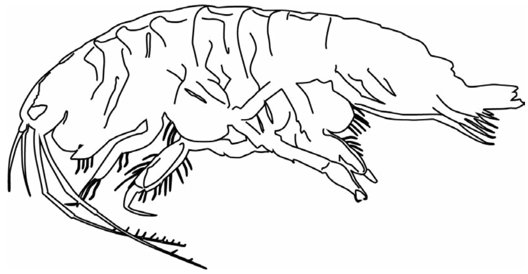
Size	0.0001cm
Max. depth	4800m
Weird rating	5/10: They can live at temperatures of over 100°C (212°F).
Predator level	○○○○
Eats	yeti crab, amphipod, scaly foot gastropod

Ghost shark



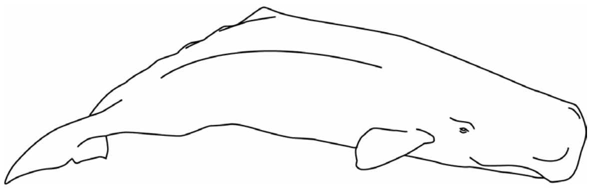
Size	150cm
Max. depth	2600m
Weird rating	4/10: Ghost sharks have not changed much in the past 340 million years.
Predator level	●●○○
Eats	vent shrimp, amphipod
Eaten by	six gill shark

Amphipod



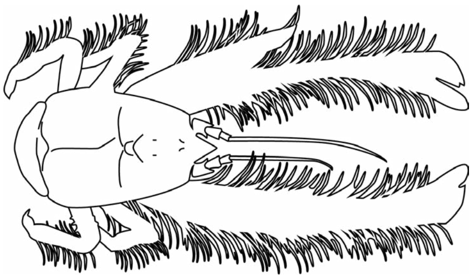
Size	34cm
Max. depth	7700m
Weird rating	2/10: They can be cannibals but are a bit like deep sea shrimps.
Predator level	●○○○
Eats	marine snow
Eaten by	dumbo octopus, dragonfish

Sperm whale



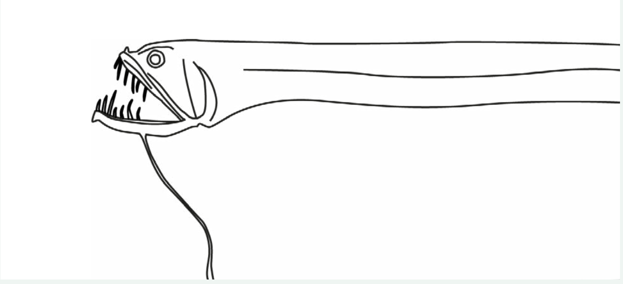
Size	1200cm
Max. depth	2250m
Weird rating	4/10: The sperm whale's teeth weigh nearly 1kg each.
Predator level	●●●●
Eats	giant squid, dumbo octopus
Eaten by	orca (not included)

Yeti crab



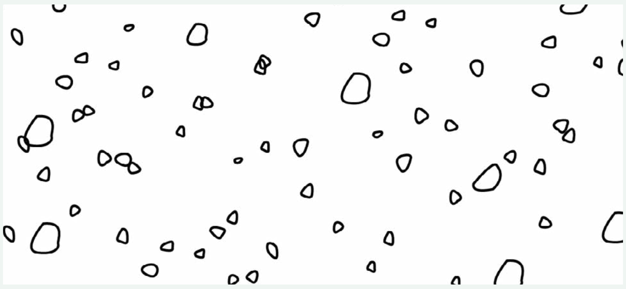
Size	15cm
Max. depth	2200m
Weird rating	8/10: They look like yetis, and garden bacteria on their hairy claws.
Predator level	●○○○
Eats	sugars from bacteria
Eaten by	ghost shark

Dragon fish



Size	15cm
Max. depth	1500m
Weird rating	6/10: Although small, they have huge teeth and a luminous barble.
Predator level	●●○○
Eats	amphipod, isopod, small fish
Eaten by	angler fish

Marine snow

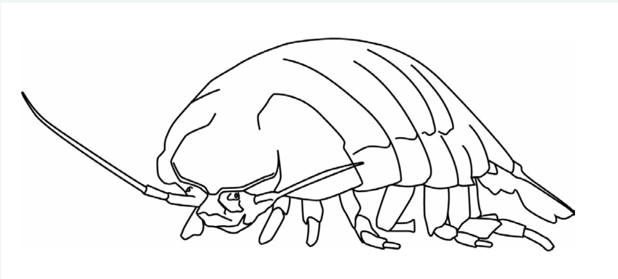


Size	0.1cm
Max. depth	10994m
Weird rating	2/10: Tiny dead animals and algae look like snow when falling through water.
Predator level	●○○○
Eaten by	amphipod, hagfish, vampire squid, sea pig, giant isopod

Vampire squid

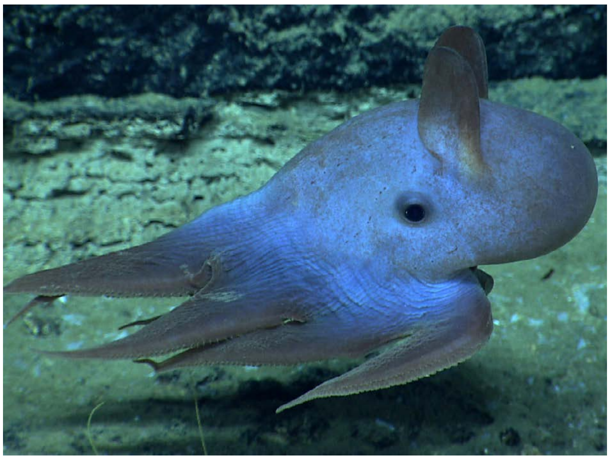
Size	15cm
Max. depth	1200m
Weird rating	7/10: Can excude flashing goo to ward off predators.
Predator level	●●○○
Eats	marine snow, amphipod
Eaten by	sixgill shark, giant squid

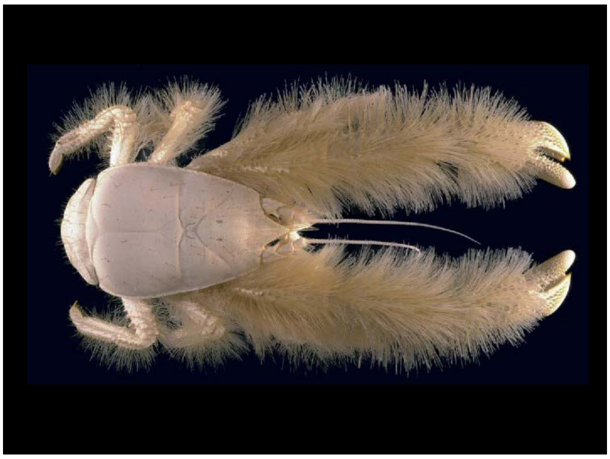
Giant ispod



Size	75cm
Max. depth	2140m
Weird rating	7/10: These are giant underwater roly polys or woodlice.
Predator level	●●○○
Eats	marine snow
Eaten by	ghost shark, six gill shark

What I would like to know





What lives in the deep sea?

Age 7-11

60 minutes

Curriculum links

- Describe the features of living things
- Describe the impact of the environment on our lives
- Ask questions, make observations, take measurements

Resources

Slideshow 2: What lives in the deep sea?

Activity Overview 2a: Ocean depths

Student Sheet 2a: Deep-sea funnies

Student Sheet 2b: Points of interest

Student Sheet 2c: Ocean zones

Diagram: Deep ocean poster

360 Gallery: Submarine science

Video: Mission Director

Subject Update: How to: Quick start to 360 VR in the classroom

Subject Update: How to: Four ways to use 360 VR in the classroom

Home learning

Students research what dangers scientists in submarines might encounter.

Lesson overview

This lesson explores the depth of the ocean through creating a scale diagram of the different ocean zones and identifying significant points within these zones. Students will consider why deep sea exploration is so challenging for humans and the different issues scientists have to overcome. This lesson allows students to examine submersibles and identify their main differences.

Lesson steps	Learning outcomes
1. **The deep sea (10 mins)** Students study Diagram: Deep ocean poster and discuss why most life exists in the sunlight zone.	• Identify living things, habitats and environments
2. **The depth of the ocean (20 mins)** Students go into the playground (or school hall) to map out a scaled version of the deep ocean and locate significant markers.	• Understand the scale and depth of the ocean • Make accurate measurements
3. **Deep sea challenges (15 mins)** Students discuss why deep ocean exploration is challenging for humans and observe different examples of submersibles.	• Explain why ocean exploration is challenging for humans • Describe how different submersibles make ocean exploration possible
4. **Mapping ocean zones (15 mins)** Students identify the deep ocean zones and add significant markers.	• Identify significant ocean zones

TEACHER GUIDANCE 2 (page 1 of 2)

Step	Guidance	Resources
1 10 mins	Step 1 introduces students to the lesson objectives and recaps the scale of the ocean. Students study the Deep ocean poster and discuss why most life exists in the sunlight zone. · Use slides to introduce lesson objectives. · Ask students to share with a partner one fact they recall from last lesson. · Show students Diagram: Deep ocean poster, highlight and discuss the names of the different zones. · Draw student's attention to the sunlight zone, discuss why so much life exists there. Draw out answers about photosynthesis, respiration and reproduction. · Discuss significant points such as the average depth of the sea floor and the deepest scuba dive.	**Slideshow 2:** Slides 1-4 **Diagram:** Deep ocean poster
2 20 mins	Step 2 takes students into the playground (or school hall) to map out a scale diagram of the ocean depths. Explain that they will be using chalk and measuring equipment to plot a scale diagram of the deep ocean (or alternatively paper and paints, see Activity 2a). · Watch Video: Mission Director on slide 5. · Organise students into small groups and provide with resources. · Allocate an area for each group to work. · Follow the activity guidance in Activity Overview 2a. Instruct children to begin plotting the scale. · After each instruction, you may wish to gather the children back to your example and partially model the next instruction and encourage them to continue independently. · Once the scales are nearing completion distribute Student Sheet 2a: Deep-sea funnies and Student Sheet 2b: Point of interest cards to groups and allow them to calculate where to place each card. · Ask students to walk around the space and view the work of other groups, noticing if there are any differences. Encourage discussion, adaption and reflection on differences. · Take photographs while students are working and on completion.	**Slideshow 2:** Slide 5 **Activity Overview 2a:** Ocean depths **Student Sheet 2a:** Deep-sea funnies **Student Sheet 2b:** Point of interest cards **Video:** Mission Director

Step	Guidance	Resources
3 15 mins	Step 3 asks students to consider why deep sea exploration is so challenging. · Using slides encourage students to think about challenges involving light, respiration and predators. · Explain that as well as these factors the water pressure in the deep sea is also problematic for humans. · Ask students how scientists explore the deep sea and take a few answers. · Using slide 9 introduce students to the different submersibles and explain their basic differences. Submarines are autonomous and can regenerate power and oxygen; submersibles rely on a surface support vessel and ROVs are unmanned and operated from the surface. · Look at 360 Gallery: Submarine science. Encourage questions and discussion.	**Slideshow 2:** Slide 6-9 **360 Gallery:** Submarine science **Subject Update:** How to: Quick start to 360 VR in the classroom **Subject Update:** How to: Four ways to use 360 VR in the classroom
4 15 mins	Step 4 involves students completing Student Sheet 2c, in which they label the ocean zones and identify points of interest. · Hand out Student Sheet 2c, which can be completed independently or in pairs. Extension: ask children to draw some of the Deep-sea funnies on their diagram at the correct depths. · Display slide 11 with word bank. · Display the learning outcomes and ask students to indicate with a show of hands whether they have achieved the outcomes. Make a note of any misconceptions to address.	**Slideshow 2:** Slide 10 **Student Sheet 2c:** Ocean zones
H/L 15 mins	Students research what dangers scientists in submarines might encounter, make a list and report back before next lesson.	

Ocean depths

Age 7-11
(adult supervision)

15 minutes

Details

What you need

- Rulers
- Meter sticks
- Tape measures
- **Student Sheet 2a:** Deep-sea funnies cards
- **Student Sheet 2b:** Point of interest cards
- **Chalk version:** coloured chalks, paved area such as playground
- **Paper version:** Poster paint, colouring pencils or pens, sticky tape, glue, scissors

Safety and Guidance

Precautions

If students are involved in creating the resources, care with scissors should be taken.

Overview

This activity allows students to map out a scale demonstrating the depth of the ocean.

Preparation

Print Student Sheet 2a and 2b and cut along dotted lines to form playing cards.

Running the Activity

This activity can be differentiated through the amount of support and modelling provided for students.

- **Chalk version:** Explain that students need to mark out a space for their ocean diagram, which should be exactly 2m long and 50 cm wide.
- **Paper version:** Instruct students to stick sheets of A4 paper together to make a rectangle measuring 2m in length.
- **Both versions:** Explain students should mark and label 1000m intervals along the side of their ocean diagram. This will divide the diagram into ten equal sections. Question: How far apart does each marker need to be? Answer: 20cm.

  Explain that as the sunlight layer is very thin students need to divide the top 1000m into five equal sections of 200m each. Question: How far apart does each marker need to be? Answer: 4cm.

  Ask the students to now mark and label the different zones on their diagrams using the information from the Deep ocean poster. Students can then shade the different layers going from light to dark to show how the sunlight only gets through the very top layers of the ocean.

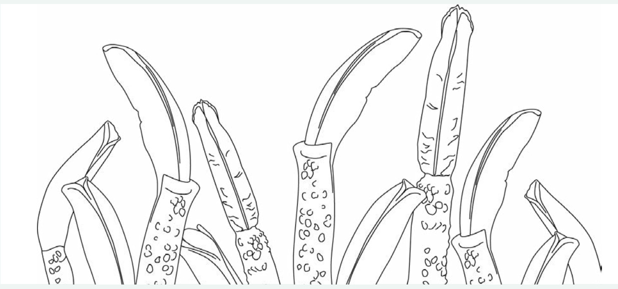
  Distribute the Deep-sea funnies and Point of interest cards to groups and ask them to calculate where each card belongs and place on the diagram. Take photographs during the activity. Allow time for students to walk around and view other groups work and discuss any differences.

Expected results

- Students will understand visually the scale and depth of the ocean and what can be found at different points.

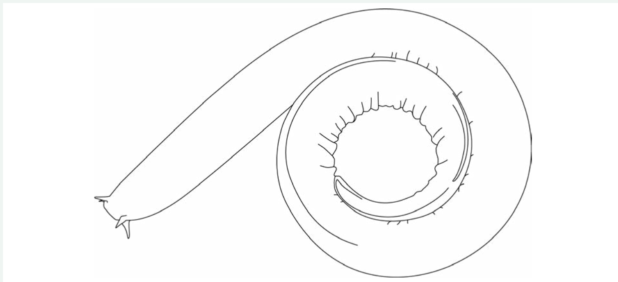
Deep-sea funnies

Giant tube worm



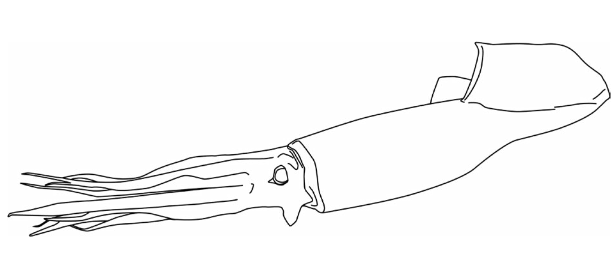
Size	240cm
Max. depth	1800m
Weird rating	8/10: Giant tube worms do not have eyes, mouth, stomach or legs.
Predator level	●○○○
Eats	sugars from bacteria
Eaten by	vent shrimp, yeti crab

Hagfish



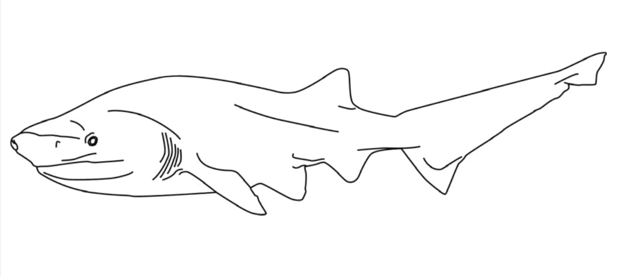
Size	50cm
Max. depth	1800m
Weird rating	8/10: Can turn a large bucket of water into slime in seconds.
Predator level	●○○○
Eats	dead sperm whales and squid
Eaten by	sixgill shark

Giant squid



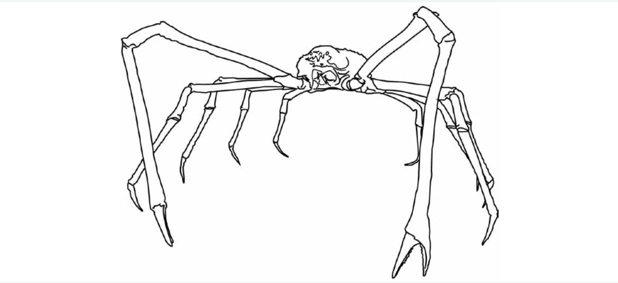
Size	1300cm
Max. depth	1000m
Weird rating	7/10: Their eyes can be 25cm across, the size of a beach ball.
Predator level	●●●○
Eats	ghost shark, six gill shark
Eaten by	sperm whale

Sixgill shark



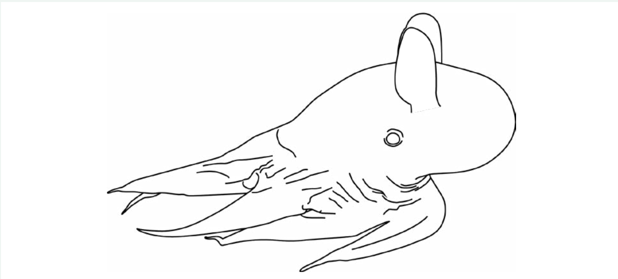
Size	490cm
Max. depth	1850m
Weird rating	5/10: This deepest shark in the world has translucent eyelids.
Predator level	●●●○
Eats	hagfish
Eaten by	orca (not included)

Japanese spider crab



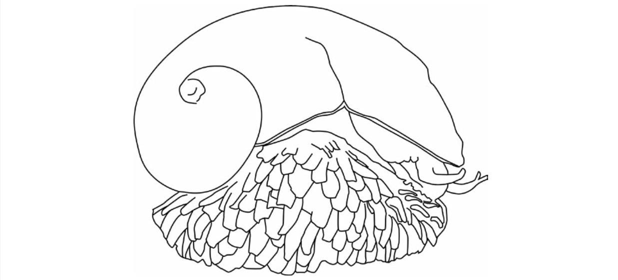
Size	380cm
Max. depth	600m
Weird rating	8/10: Truly frightening, with legs that stretch 1.6 meters.
Predator level	●●○○
Eats	mussels, sea pigs
Eaten by	large octopus (not included)

Dumbo octopus



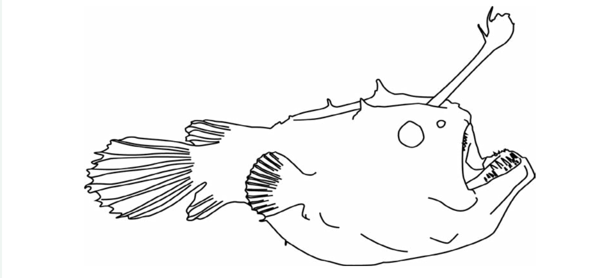
Size	30cm
Max. depth	7000m
Weird rating	6/10: They look like a cartoon elephant.
Predator level	●●○○
Eats	amphipods, isopods
Eaten by	sperm whale

Scaly foot gastropod



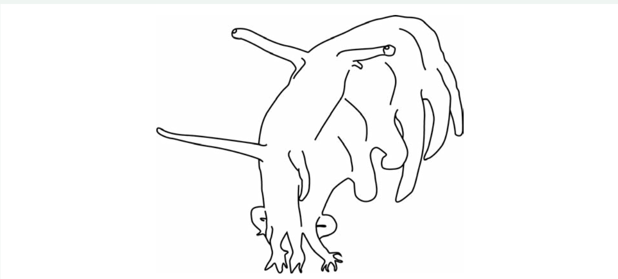
Size	4cm
Max. depth	2800m
Weird rating	6/10: This small snail makes armour plating from iron in the seawater.
Predator level	●○○○
Eats	sugars from bacteria
Eaten by	yeti crab

Angler fish



Size	15cm
Max. depth	4500m
Weird rating	9/10: When mating, the smaller male fuses to the female's body.
Predator level	●●○○
Eats	amphipod, dragon fish
Eaten by	giant squid

Sea pig

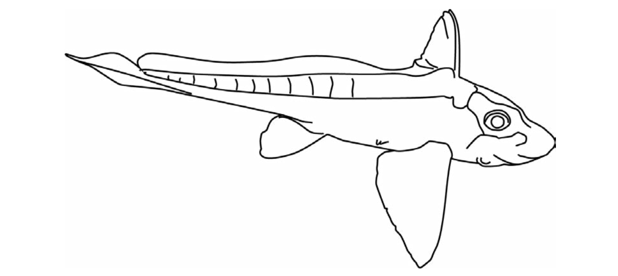


Size	20cm
Max. depth	5000m
Weird rating	5/10: The sea pig is the only sea cucumber to have 'legs'.
Predator level	●○○○
Eats	marine snow
Eaten by	giant isopod, spider crab

Vent bacteria

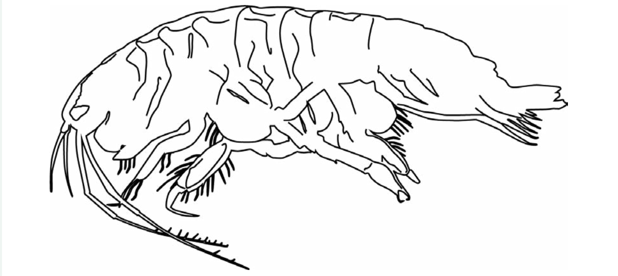
Size	0.0001cm
Max. depth	4800m
Weird rating	5/10: They can live at temperatures of over 100°C (212°F).
Predator level	○○○○
Eats	yeti crab, amphipod, scaly foot gastropod

Ghost shark



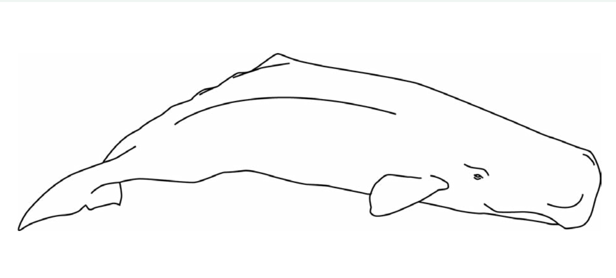
Size	150cm
Max. depth	2600m
Weird rating	4/10: Ghost sharks have not changed much in the past 340 million years.
Predator level	●●○○
Eats	vent shrimp, amphipod
Eaten by	six gill shark

Amphipod



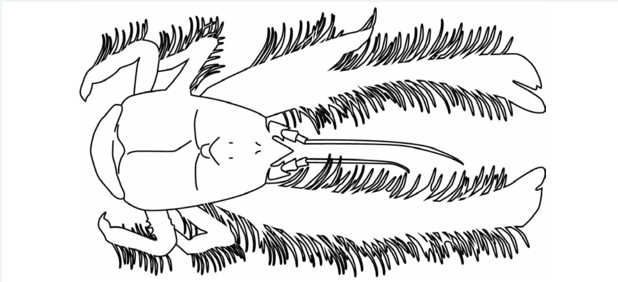
Size	34cm
Max. depth	7700m
Weird rating	2/10: They can be cannibals but are a bit like deep sea shrimps.
Predator level	●○○○
Eats	marine snow
Eaten by	dumbo octopus, dragonfish

Sperm whale



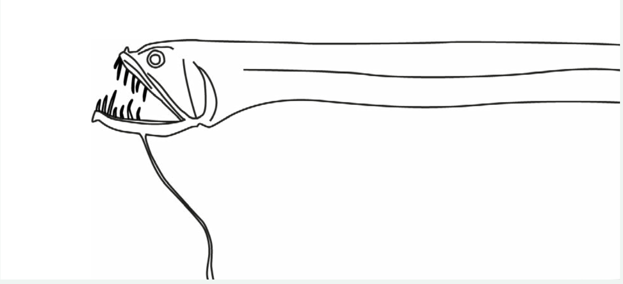
Size	1200cm
Max. depth	2250m
Weird rating	4/10: The sperm whale's teeth weigh nearly 1kg each.
Predator level	●●●●
Eats	giant squid, dumbo octopus
Eaten by	orca (not included)

Yeti crab



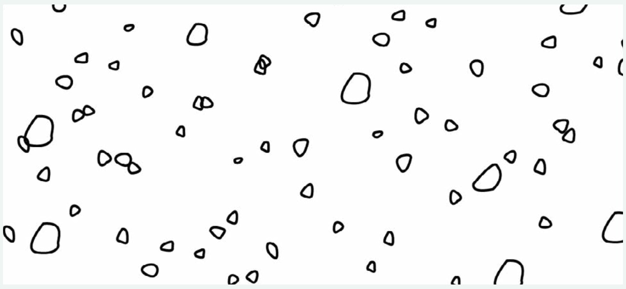
Size	15cm
Max. depth	2200m
Weird rating	8/10: They look like yetis, and garden bacteria on their hairy claws.
Predator level	●○○○
Eats	sugars from bacteria
Eaten by	ghost shark

Dragon fish



Size	15cm
Max. depth	1500m
Weird rating	6/10: Although small, they have huge teeth and a luminous barble.
Predator level	●●○○
Eats	amphipod, isopod, small fish
Eaten by	angler fish

Marine snow

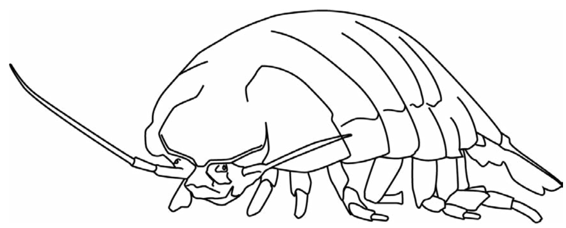


Size	0.1cm
Max. depth	10994m
Weird rating	2/10: Tiny dead animals and algae look like snow when falling through water.
Predator level	●○○○
Eaten by	amphipod, hagfish, vampire squid, sea pig, giant isopod

Vampire squid

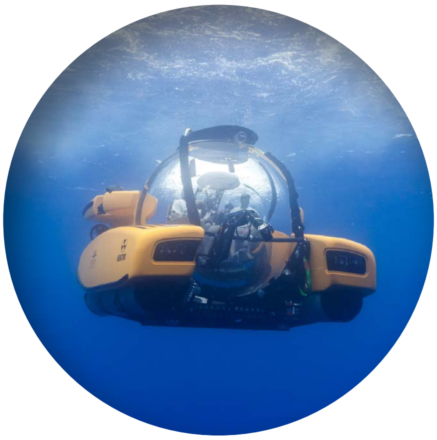
Size	15cm
Max. depth	1200m
Weird rating	7/10: Can excude flashing goo to ward off predators.
Predator level	●●○○
Eats	marine snow, amphipod
Eaten by	sixgill shark, giant squid

Giant ispod



Size	75cm
Max. depth	2140m
Weird rating	7/10: These are giant underwater roly polys or woodlice.
Predator level	●●○○
Eats	marine snow
Eaten by	ghost shark, six gill shark

Point of interest cards



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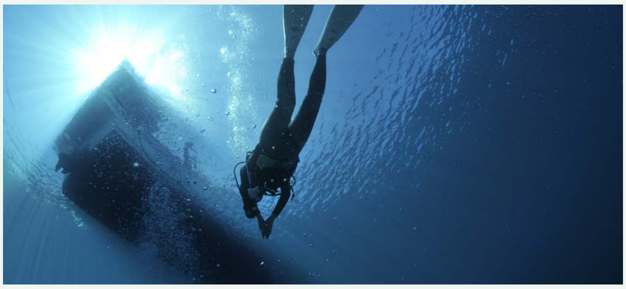


POI: Nuno Gomes deepest scuba dive in 2005.

Depth: 318m

Did you know? Gomes holds two world records for deep sea diving and cave diving. To put this into context, most recreational scuba diving takes place between 0m and 25m.

POI: Average depth of the ocean.

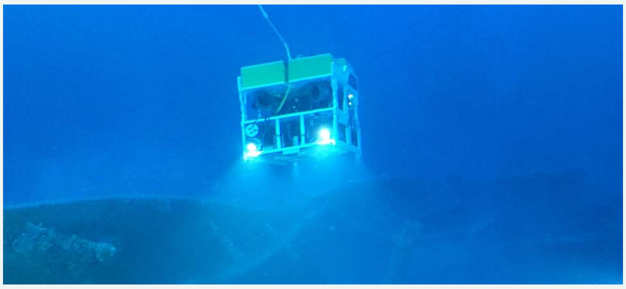
Depth: 3790m

Did you know? The first manned dives to the deep ocean took place in 1930. They were conducted by Beebe and Barton off the coast of Bermuda to a depth of 245m.

POI: Triton Submersible 1000/2

Depth: 305m

Did you know? Submersibles and submarines have been used by navies and scientists for decades. Now it is possible for the public to buy them too, if you have a spare few million dollars.



POI: Remotely Operated Vehicle (ROV)

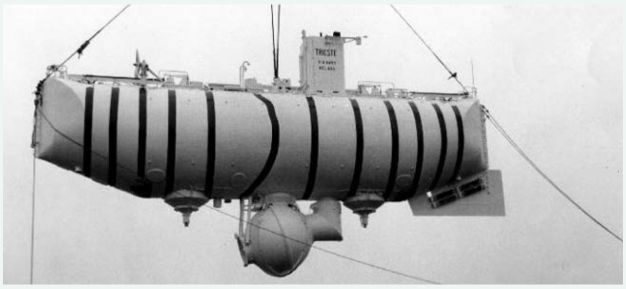
Depth: 10000m

Did you know? ROVs are an easier way to explore the deep sea as they do not need to carry humans. These underwater robots are remote controlled, with operators using a video feed to see and a joystick to control movement.

POI: The Milwaukee Deep (deepest point in the Atlantic Ocean)

Depth: 8400m [referencing NOAA and USGS]

Did you know? This is close to the height of Mount Everest , which rises to 8848m above sea level.



POI: Bathyscaphe Trieste first human voyage to deepest point in 1960.

Depth: 10994m

Did you know? The descent took 4 hours 47 minutes, with pilots Jacques Piccard and Don Walsh the only people to have descended to the bottom of the ocean, until James Cameron repeated the feat in 2012.

STUDENT SHEET 2c

Ocean zones

200m	Zone:
1000m	Zone:
2000m 3000m 4000m	Zone:
5000m 6000m	Zone:
7000m 8000m 9000m 10994m	Zone:

What forces affect submarines?

Age 7-11

60 minutes

Curriculum links

- Explain how gravity acts as a force
- Identify the effects of water resistance
- Take measurements, make predictions and draw conclusions

Resources

Slideshow 3: What forces affect submarines?

Activity Overview 3a: Submersible shape investigation

Student Sheet 3a: Shape investigation

360 Gallery: Diving in a submarine

Subject Update: How to: Quick start to 360 VR in the classroom

Subject Update: How to: Four ways to use 360 VR in the classroom

Home learning

Students research how sea creatures have adaptations which help them move efficiently through the water.

Lesson overview

The context of the lesson is a practical investigation to discover how shape and surface area affect the speed at which a submersible descends. Students develop their understanding of forces, surface area, and fair testing.

Lesson steps	Learning outcomes
1. **Forces mini quiz (15 mins)** Students take a forces mini quiz in groups to assess their level of understanding and open a discussion about gravity.	• Understand gravity as a force
2. **Virtual submarine dive (10 mins)** Students take a virtual submarine dive and consider how forces might impact on submersible design.	• Consider how forces affect submersibles
3. **Shape investigation (20 mins)** Using modelling clay students investigate how a variety of shapes move at different speeds through water. Making predictions, students test different shapes and measure speed ensuring it is a fair test.	• Investigate how shape affects the speed • Predict and test with accuracy
4. **Understanding water resistance (15 mins)** Students describe why shapes move at different speeds using scientific vocabulary to explain their findings.	• Describe how forces affect submersibles

TEACHER GUIDANCE 3 (page 1 of 2)

Step	Guidance	Resources
1 15 mins	Step 1 introduces students to the lesson objectives. Students then take a mini quiz, to assess what they already know about gravity and forces and to open a discussion which quickly establishes basic facts. · Use slides to introduce lesson objectives. · Put students into small mixed ability groups, reveal each slide and read aloud the question. Allow the groups a few minutes to discuss and decide on their answer. · Encourage students with accurate subject knowledge to explain their answers to the class. Briefly explain any gaps in understanding.	**Slideshow 3:** Slide 1-7
2 20 mins	Students explore the Diving in a submarine panoramas in the Encounter Edu 360VR gallery or on the Google Expeditions platform. · Ask students to consider how gravity, water resistance and upthrust might affect submersibles. Students discuss in pairs and feed back.	**Slideshow 3:** Slide 8 **360 Gallery:** Diving in a submarine **Subject Update:** How to: Quick start to 360 VR in the classroom **Subject Update:** How to: Four ways to use 360 VR in the classroom
3 20 mins	Step 3 asks students to think about which shapes would move quickly through water. Use slides to demonstrate the method for the investigation. · Give each student a pre-portioned piece of modelling clay. All the pieces should be the same mass. · Ask students to make a shape with their clay that will move very quickly through water. · Once they have moulded their shape, look at a few ideas and ask students to explain why they have chosen that shape. Drawing out answers which focus on their experiences of fast things. · Explain that students will be doing a practical experiment to investigate how shape affects speed. The practical investigation involves dropping different shapes made from modelling clay into a cylinder of water. The time taken for the shape to fall through the water will depend on the mass of the modelling clay and the size of the cylinder. These will vary from school to school. It is suggested that you trial this activity, to find a mass of modelling clay, when pressed flat, that will fall through the cylinder of water at the target rate. See Activity 3a for more details.	**Slideshow 3:** Slide 9-17 **Activity Overview 3a:** Submersible shape investigation

Step	Guidance	Resources
	· This activity can either be conducted using large measuring cylinders or large clear plastic containers. If using cylinders, inform students they should mould their clay around a paper clip and attach that to a piece of string, so they are able to retrieve their model after each test. Alternatively, if using large plastic containers, students can simply reach in and extract the model after each attempt. Have paper towels handy in case of spills. · Use Activity Overview 3a for further guidance on how to run this activity. Ask students what makes a fair test, draw out answers around only changing one variable and ensuring all others remain the same. Ask students for examples of how they will make this a fair test.	
4 15 mins	Step 4 uses slides 18-24 to explain why shapes move at different speeds, the affect of gravity, water resistance and up-thrust and asks students to explain their findings. · Go through slides drawing student's attention to the key vocabulary as they view the images. · Encourage students to answer questions and clarify meanings. · Students return to Student Sheet 3a and complete statements about the forces that affect submersibles. · Display the learning outcomes and ask students to indicate with a show of hands whether they have achieved the outcomes. Make a note of any misconceptions to address.	**Slideshow 3:** Slide 18-24 **Student Sheet 3a:** Shape investigation
H/L 15 mins	Students research how sea creatures have adaptations which help them move efficiently through the water. Prepare three examples to share.	

Submersible shape investigation

Age 7-11
(adult supervision)

20 minutes

Details

What you need

- **Student Sheet 3a:** Shape investigation
- **Cylinders version:** large measuring cylinders, paper clips, string
- **Plastic version:** large, clear plastic containers, paper towels
- **Both version:** modelling clay, timers / stop watches

Safety and Guidance

Precautions

Caution should be taken to ensure that containers are not too full. To avoid spills keep containers in the middle of the table and clean up spills straight away to avoid slips. Students must not ingest the modelling clay or water.

Overview

This activity allows students to test the speed at which different shapes travel through water.

Preparation

Portion the modelling clay into enough pieces for one per student ensuring they all have the same mass. Fill large cylinders or large plastic containers with water and distribute to groups / pairs.

Running the Activity

- Display the slides and demonstrate choosing and moulding a shape. Demonstrate and explain why it is important that each drop takes place from the waters surface and does not have any additional force applied. Ask students why it is important to do this. Model working with a partner where one executes the drop and the other times the descent and then swap. Remind students to record their results as they go.
- If using cylinders, inform students they should mould their clay around a paper clip and attach it to a piece of string, so they are able to retrieve their model after each test. Alternatively, if using large plastic containers, students can simply reach in and extract the model after each attempt. Have paper towels handy in case of spills.
- Explain that they have about five minutes to try out some different shapes which move quickly and slowly through the water. Then they should turn their attention to the investigation.
- Explain that the task is to find a shape which takes exactly 7 seconds (or the time you specify) to descend to the bottom of the container. First, they should make a prediction and draw the shape they think will take 7 seconds on Student Sheet 3a. Then test and time the descent. They can then retrieve the model and make changes to its shape and retest, to see if they can be more precise.
- After two attempts they should discuss with their partner why the changes they made were / weren't successful, using scientific vocabulary and then write their own conclusion on Student Sheet 3a.

Expected results

- Students should find that streamlined shapes should fall through the water more quickly, and flatter shapes with a larger surface area are slower.

STUDENT SHEET 3a

Shape investigation

Obtaining Evidence

Shape	Time	Shape	Time
1.		2.	
3.		4.	

Prediction

Prediction	Shape

Results

Attempt 1	Time

Attempt 2	Time

Word Bank

gravity, water resistance, force, area, mass

Conclusion

How do you choose materials for a submarine?

Age 7-11

60 minutes

Curriculum links

- Compare and group materials
- Give reasons for uses of materials
- Suggest improvements and raise further questions

Resources

Slideshow 4:
How do you choose materials for a submarine?

Student Sheet 4a:
Material cards

Student Sheet 4b:
My submersible materials

Student Sheet 4c:
Salt water investigation

360 Video:
Submarine launch

Subject Update:
How to: Quick start to 360 VR in the classroom

Subject Update:
How to: Four ways to use 360 VR in the classroom

Home learning

Students watch video at www.encounteredu.com/discover/videos/exploring-the-deep-ocean and write a short list of items they would take with them on a deep-sea dive, justifying their choices.

Lesson overview

This lesson discusses the properties of materials and their use in submersible design. Students will compare a variety of materials for their submersible and justify their choices. An investigation into how salt water affects materials allows pupils to make predictions, write conclusions and conduct a fair test.

Lesson steps	Learning outcomes
1. **History of submarines (10 mins)** Students explore historical designs of submarines and discuss the pros and cons of each design and its material construction.	• Discuss the properties of materials
2. **Choosing materials (10 mins)** Students are guided through the design process and make suggestions for what each element of the submersible could be constructed from.	• Compare and group materials based on their properties
3. **Comparing materials (10 mins)** Students study the properties of a range of materials and decide which would be suitable or unsuitable for a submersible.	• Give reasons for the uses of materials
4. **Submersible design (15 mins)** Using prior learning about submersible shapes, students make a rudimentary design and specify which materials parts of the structure would be made from.	• Explain the suitability of materials for certain uses
5. **Salt water experiment (15 mins)** Students make predictions about how submersion in salt water will affect different materials.	• Make predictions about how salt-water affects materials

TEACHER GUIDANCE 4 (page 1 of 2)

Step	Guidance	Resources
1 10 mins	Step 1 introduces students to the learning outcomes. Students then explore some historical submarine designs and discuss their pros and cons. · Use slides to introduce lesson objectives. · Go through slides 4-8 reading the basic information. · Ask children to share their thoughts about each design and discuss the pros and cons of the materials and construction of each submersible. · Ask students to think about what modern submersibles are constructed from. · Watch Video: 360 Submarine launch and ask students what materials they think the Triton Submarine might be made of.	**Slideshow 4:** Slides 1-9 **360 Video:** Submarine launch
2 10 mins	Step 2 guides students through the design process through a series of questions about the suitability of different materials. · Using slides describe each element of the submarines construction and ask students to make suggestions for a suitable material. · Ask students to agree or disagree with each other's suggestions and clarify why.	**Slideshow 4:** Slide 10-13
3 10 mins	In step 3, students compare a range of materials and make choices about the suitability of each material for submersible construction. If you have access to real life examples of any of these materials, allow students an opportunity to examine them. · Hand out Student Sheet 4a: Materials cards. · In small groups students study the cards and share the properties of each material, making suggestions for which element of the submersible this would be suitable or unsuitable for. · Using slide 14 ask students to suggest which material they think would be most suitable and why. Take two answers for each element.	**Slideshow 4:** Slides 14 **Student Sheet 4a:** Material cards

TEACHER GUIDANCE 4 (page 2 of 2)

Step	Guidance	Resources
4 15 mins	Step 4 asks students to make a simple submersible design and suggest the most suitable materials for construction. Use slides to introduce lesson objectives. · Remind students to think back to last lesson when they investigated how shape would affect how the submersible moves. · Model drawing a simple shape for your submersible. Use Student Sheet 4b as a guide for students who may need more support. · Annotate the design with the materials you might use for each element. · Model writing a brief explanation for the first element giving reasons for your choice i.e. I would use clear acrylic for the window as it is transparent and stronger than glass. · Explain that students will complete Student Sheet 4b with their own design choices.	**Student Sheet 4b:** My submersible materials
5 15 mins	In step 5 students observe a range of the materials discussed and make predictions about how salt water will affect them. · Show students the materials you have collected. · Explain that in each container is a salt water solution. · Explain that each of the materials will be placed in the solution for a specified number of days. · Ask students to make predictions about what will happen to each material after the specified number of days. Relate this to the submersible conditions and explain they will need to remove each item periodically, then submerge it again. Ask how we will test this fairly. · Ask students to make predictions about three of the materials in the investigation on Student Sheet 4c. · After the specified number of days, when you have 15 minutes examine the materials with the students. Ask them to describe what they observe. Complete the results and conclusion section of Student Sheet 4c. · Review the learning outcomes with a show of hands.	**Slideshow 4:** Slide 15-18 **Student Sheet 4c:** Salt water investigation
H/L 15 mins	Students watch video at www.encounteredu.com/discover/videos/exploring-the-deep-ocean. Write a short list of items you would take with you on a deep sea dive, justifying your choices.	

Materials cards

Fibreglass

Density	●●○○○
Cost	●●○○○
Malleability	●○○○○
Strength	●○○○○
Transparency	●●○○○

Tough material used to make the hulls of lightweight yachts.

Brass

Density	●●●●○
Cost	●●○○○
Malleability	●●●○○
Strength	●●●●○
Transparency	○○○○○

An alloy, used to make musical instruments.

Polystyrene

Density	●○○○○
Cost	●○○○○
Malleability	●○○○○
Strength	○○○○○
Transparency	○○○○○

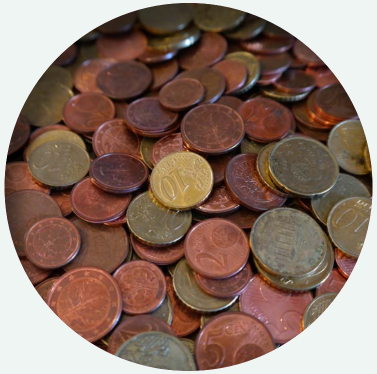
Cheap, used as insulation and packing material.

Clear Acrylic

Density	●●○○○
Cost	●●○○○
Malleability	●●●○○
Strength	●●●●○
Transparency	●●●●●

Transparent, hard and often used instead of glass for items such as kitchenware.

Copper



Density	●●●●●
Cost	●○○○○
Malleability	●●●○○
Strength	●●●●○
Transparency	○○○○○

Used to make coins and for plumbing.

Stainless Steel

Density	●●●●●
Cost	●○○○○
Malleability	●●●○○
Strength	●●●●○
Transparency	○○○○○

Strong, cheap alloy used to make the structures of buildings and vehicle bodies. Does not rust easily.

Wood

Density	●○○○○
Cost	●○○○○
Malleability	●○○○○
Strength	●●○○○
Transparency	○○○○○

Readily available material used to build furniture and the frames of houses.

Aluminium

Density	●●○○○
Cost	●○○○○
Malleability	●●●○○
Strength	●●●○○
Transparency	○○○○○

Commonly used for building the bodies of aeroplanes. Does not rust.

Rubber

Density	●○○○○
Cost	●○○○○
Malleability	●●●●●
Strength	●●●●○
Transparency	○○○○○

Flexible and soft insulator that is cheap and easy to obtain.

Carbon Fibre

Density	●●○○○
Cost	●●●●○
Malleability	●●●○○
Strength	●●●●○
Transparency	○○○○○

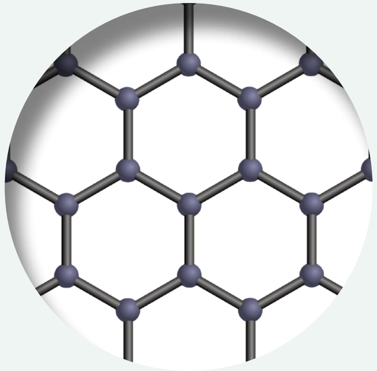
Strong, lightweight material used to make expensive bicycles for athletes and bullet-proof vests.

Iron

Density	●●●●●
Cost	●○○○○
Malleability	●●●○○
Strength	●●●●○
Transparency	○○○○○

Relatively soft but heavy metal that rusts easily. Used to make steel.

Graphene



Density	●○○○○
Cost	●●●●○
Malleability	●●●●●
Strength	●●●●●
Transparency	○○○○○

Expensive nano-material difficult to obtain in large quantities. Used to make electronics.

Graphite

Density	●●○○○
Cost	●○○○○
Malleability	○○○○○
Strength	●○○○○
Transparency	○○○○○

Cheap, soft material used to make pencils. Conducts heat and electricity.

Glass

Density	●●○○○
Cost	●○○○○
Malleability	●○○○○
Strength	●●○○○
Transparency	●●●●●

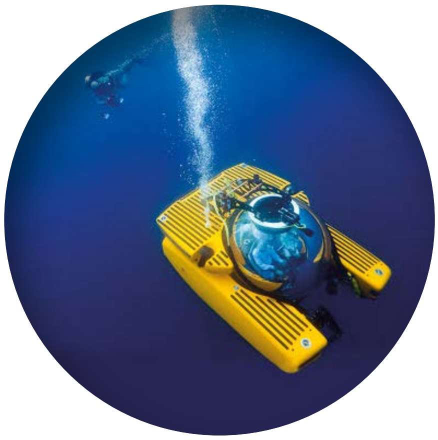
Transparent material that can be made into sheets for windows and moulded into shapes for bottles and containers.

Titanium

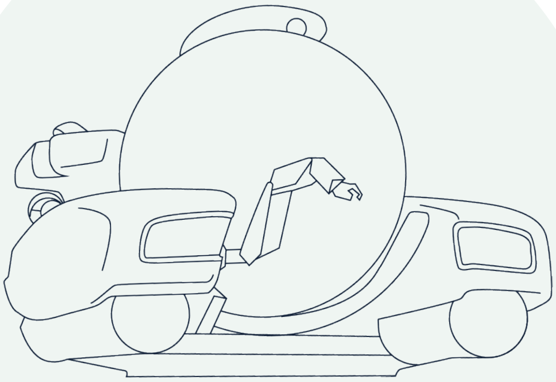
Density	●●●●○
Cost	●●●●○
Malleability	●●●●○
Strength	●●●●●
Transparency	○○○○○

Very strong, light metal. Does not rust. Used to make replacement hip joints.

My submersible materials



Design your own submersible and label the materials you would use. Justify your choices.



Salt water investigations

Choose three materials to submerge in salt water for .... days.

Things we will change

Material 1	Material 2	Material 3

Things we will keep the same

Predictions

Material 1	Material 2	Material 3

Results

Conclusion

How do you launch a submarine with strong structures?

Age 7-11

60 minutes

Curriculum links

- Explain how machines can help us
- Use knowledge of materials to make suitable choices
- Plan, investigate, record and make conclusions

Resources

Slideshow 5:
How do you launch a submarine with strong structures?

Activity Overview 5a:
Designing a crane

Activity Overview 5b:
Submersible model

Student Sheet 5a:
Designing a crane

360 Video:
Submarine launch

Subject Update:
How to: Quick start to 360 VR in the classroom

Subject Update:
How to: Four ways to use 360 VR in the classroom

Home learning

Students construct a model submarine to be launched and recovered in Lesson 6.

Lesson overview

Part one of this two-part lesson develops students understanding of strong structures and investigates how cranes work. Students work together to design and construct a crane using a variety of materials. They will adapt and evaluate their structure as they go along and make improvements where necessary. They will also construct a model submersible to launch and recover once their crane is complete.

Lesson steps	Learning outcomes
1. **Launching a submarine (10 mins)** Students consider how submarines are launched from the surface vessel and watch a 360 video of a launch.	• Describe how machines help people
2. **Strong structures (10 mins)** Students examine the features of strong structures and how this relates to building a crane.	• Describe and apply the features of a stable structure
3. **Plan and build (30 mins)** In pairs students plan and build a crane structure that will be capable of launching and recovering a model submarine.	• Construct a working model of a crane
4. **Evaluate and improve (10mins)** Students evaluate and improve their build and begin planning the next element of their machine.	• Reflect on learning and plan next steps

TEACHER GUIDANCE 5 (page 1 of 3)

Step	Guidance	Resources
1 10 mins	Step 1 introduces students to the learning outcomes. Students then consider how scientists launch submersibles from the surface vessel. · Use slides to introduce lesson objectives. · Ask students how they think the expedition crew get the submarine from the surface vessel into the water. · Show students slide 4 and ask them to talk to their partner about what they can see. · Discuss the importance of carefully and safely launching submarines. How could machines help in this situation in terms of lifting heavy and fragile equipment and accurately positioning it? Ask students to suggest what would happen if we didn't have machines to help us in this situation. · Watch 360 Video: Submarine launch, moving around the panorama to draw students attention to the features of the launch vessel, crane, lever and pulley system. · Explain that this is part one of a two-part lesson, over the course of the two lessons students will be designing, building and evaluating their own launch and recovery system.	**Slideshow 5:** Slide 1-5 **360 Video:** Submarine launch **Subject Update:** How to: Quick start to 360 VR in the classroom **Subject Update:** How to: Four ways to use 360 VR in the classroom
2 10 mins	In step 2 students identify the features of strong structures and identify the features of a crane. · Display slides 6-10, ask students to talk to a partner about the structures they can see and identify what makes it a strong structure. · Once students have viewed slides 6-10 ask them to discuss in pairs the common features of those structures and feed back. Draw out answers relating to triangular structures. · Display slides 11-19 and talk through the features of a crane, allowing students to input their ideas and experience of seeing these mechanisms in real life. Ask how each element of the crane helps the machine complete tasks that would be difficult for humans.	**Slideshow 5:** Slides 6-19

TEACHER GUIDANCE 5 (page 2 of 3)

Step | **Guidance** | **Resources**

3
30 mins

Step 3 introduces the task of building a machine capable of launching and recovering a submarine which students will complete over the next two lessons. Several materials need to be collected prior to the lesson, a full list is included in Activity Overview 5a, it may be necessary to ask students to collect and bring items from home, prior to starting the build.

- Explain that students will be building a launch and recovery machine and that the first step is to build a crane.
- Look at slide 21 to remind students of the structure they are aiming for.
- Direct students' attention to the materials they will have access to.
- In pairs allow students 5-10 minutes to discuss with their partner and make some notes / sketches on Student Sheet 5a.
- Explain that these initial ideas can be revised as they go along as they will be using trial and error to construct their crane. Therefore, making mistakes is useful to learn from and improve their design.
- Use Activity Overview 5a to brief students and model ideas and concepts where necessary.
- Explain that they will be working in pairs and at some points they will need two sets of hands to complete tasks, sometimes partners will need to be working on separate tasks and sometimes one partner will need to be evaluating and improving the design, so they need to be as efficient as possible.
- Tell students to begin their build, give frequent reminders of how much time they have left this lesson so there is enough time at the end to clear away and safely store structures.
- Take photographs of the students during construction and on completion.

Resources:

Slideshow 5:
Slides 20-21

Activity Overview 5a:
Building a crane

Student Sheet 5a:
Designing a crane

4
10 mins

Step 4 asks students to evaluate their structure and start the next phase of planning.

- Once students have built a crane structure they can use Student Sheet 5a to evaluate their build and suggest any changes they would make.
- The time Step 3 takes will vary from group to group; some students may require more support than others. There is scope to continue this build into the next lesson if necessary.
- If students do complete the crane build in this lesson, they should complete Student Sheet 5a. If they do not they can complete Student Sheet 5a at another time, or in the next lesson.

Resources:

Slideshow 5:
Slide 22

Activity Overview 5a:
Building a crane

Student Sheet 5a:
Designing a crane

TEACHER GUIDANCE 5 (page 3 of 3)

Step	Guidance	Resources
4 10 mins	· If students complete the crane build and Student Sheet 5a in this lesson you may wish to set the extension activity in Activity Ovevrview 5b. This can also be set as home learning for students to complete before the next lesson. · Display slide 22 for students to check they have completed all tasks. · Review learning outcomes with a show of hands. · Assess how much more time students need to complete their crane structure before the next lesson.	
H/L 20 mins	Students construct a model submarine using Activity 5b.	**Activity Overview 5b:** Submersible model

Building a crane

Age 7-11
(adult supervison)

30 minutes

Details

What you need

- **Student Sheet 5a:** Shape investigation
- A4 paper or card - 6 per group
- 20cm lengths of wooden dowel (6mm diameter) - 4 per group
- Masking tape / sticky tape
- Hole-punches
- Shoe boxes - 1 per group

Safety and Guidance

Precautions

Ensure dowel is not sharp at each end, if students are involved in the preparation of resources great care should be taken when sawing wood and using scissors.

Overview

In this activity students construct a crane, which will go on to launch and recover their submersibles.

Preparation

Cut the dowel into 20cm lengths.

Running the Activity

You might want your students to lead this activity themselves and simply provide them with materials and allow them to build a structure of their own design which meets the specification. The frame of the crane is constructed using roll-tube structures which are simply paper or card tubes, rolled accurately using thick wooden dowel and taped in the middle and near the ends to prevent unrolling. The roll tubes have holes punched in the ends using a hole-punch which allows them to be joined together with wooden dowels (or similar). However, a step-by-step guided to building a crane follows.

1. Students tightly roll sheets of A4 paper landscape, around the dowel keeping it as tight as possible.
2. Remove dowel so you have a thin paper cylinder. Secure with tape in the middle and 3cm from the end.
3. Flatten both ends of the tube then place into a hole-punch and make a hole. Reform the flattened ends into cylinders.
4. Students make four this size. Then repeat above but with A4 sheets portrait. Students make two this size. Punch two holes in the middle of both long tubes.
5. Use wooden dowels (6mm diameter) to twist through the holes and join the tubes together to make a triangular structure. This forms the basis of the crane and can be attached to the shoe box (surface vessel) at one end with sticky tape. Dowels can be easily removed from the structure, to add the pulley system in the next lesson.

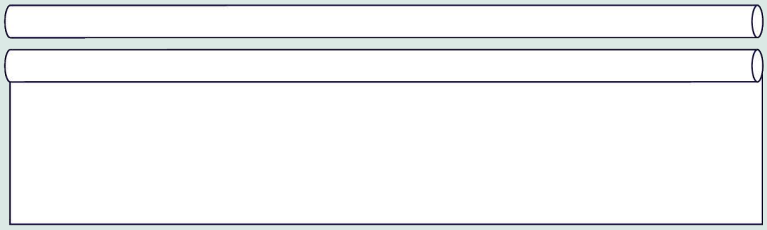
Expected results

- Students using a triangular structure will build stable structures.

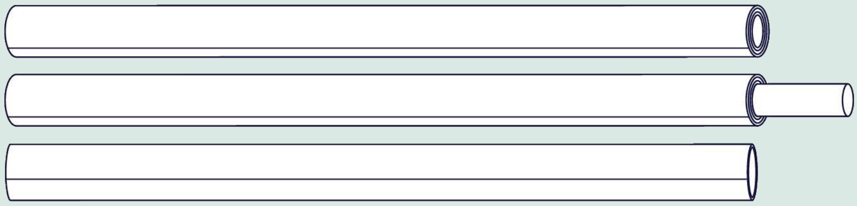
ACTIVITY OVERVIEW 5a

Running the Activity

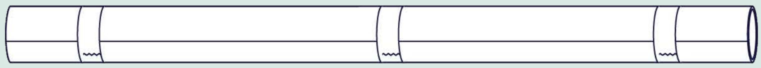
1. Students tightly roll sheets of A4 paper landscape, around the dowel keeping it as tight as possible.



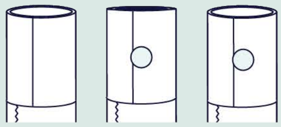
2. Remove dowel so you have a thin paper cylinder.



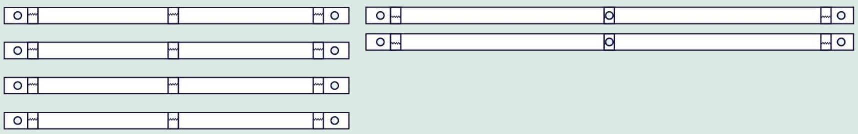
   Secure with tape in the middle and 3cm from the end.



3. Flatten both ends of the tube then place into a hole-punch and make a hole. Reform the flattened ends into cylinders.

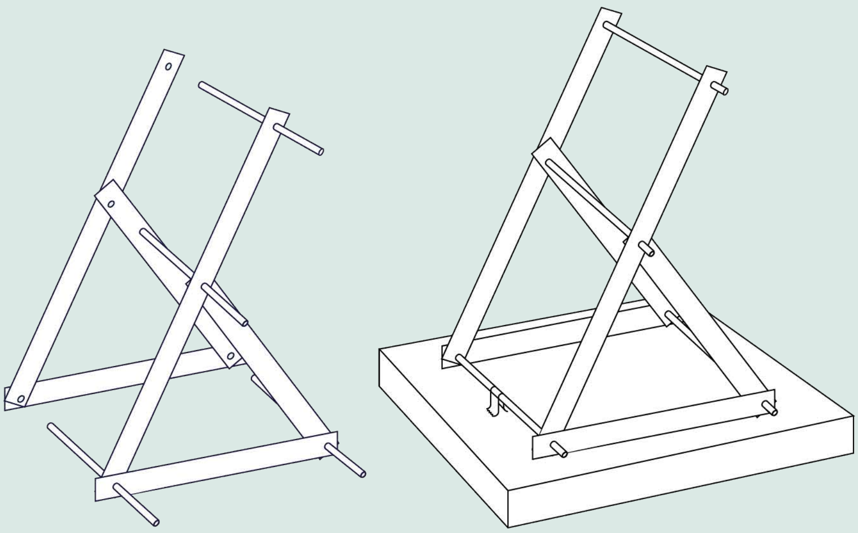


4. Students make four this size. Then repeat above but with A4 sheets portrait. Students make two this size. Punch two holes in the middle of both long tubes.



5. Use wooden dowels (6mm diameter) to twist through the holes and join the tubes together to make a triangular structure.

   This forms the basis of the crane and can be attached to the shoe box (surface vessel) at one end with sticky tape. Dowels can be easily removed from the structure, to add the pulley system in the next lesson.



Submersible model

Age 7-11
(adult supervision)

15 minutes

Details

What you need

- A4 Card
- Sticky tape or glue stick
- String

Safety and Guidance

Precautions

Care with scissors should be taken.

Overview

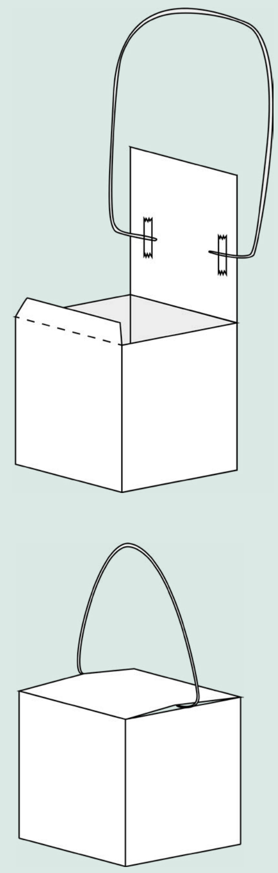
This activity creates a small, light submersible model for students to launch and recover once they have built their machine.

Preparation

Students should find a cube net template online, or one is provided below.

Running the Activity

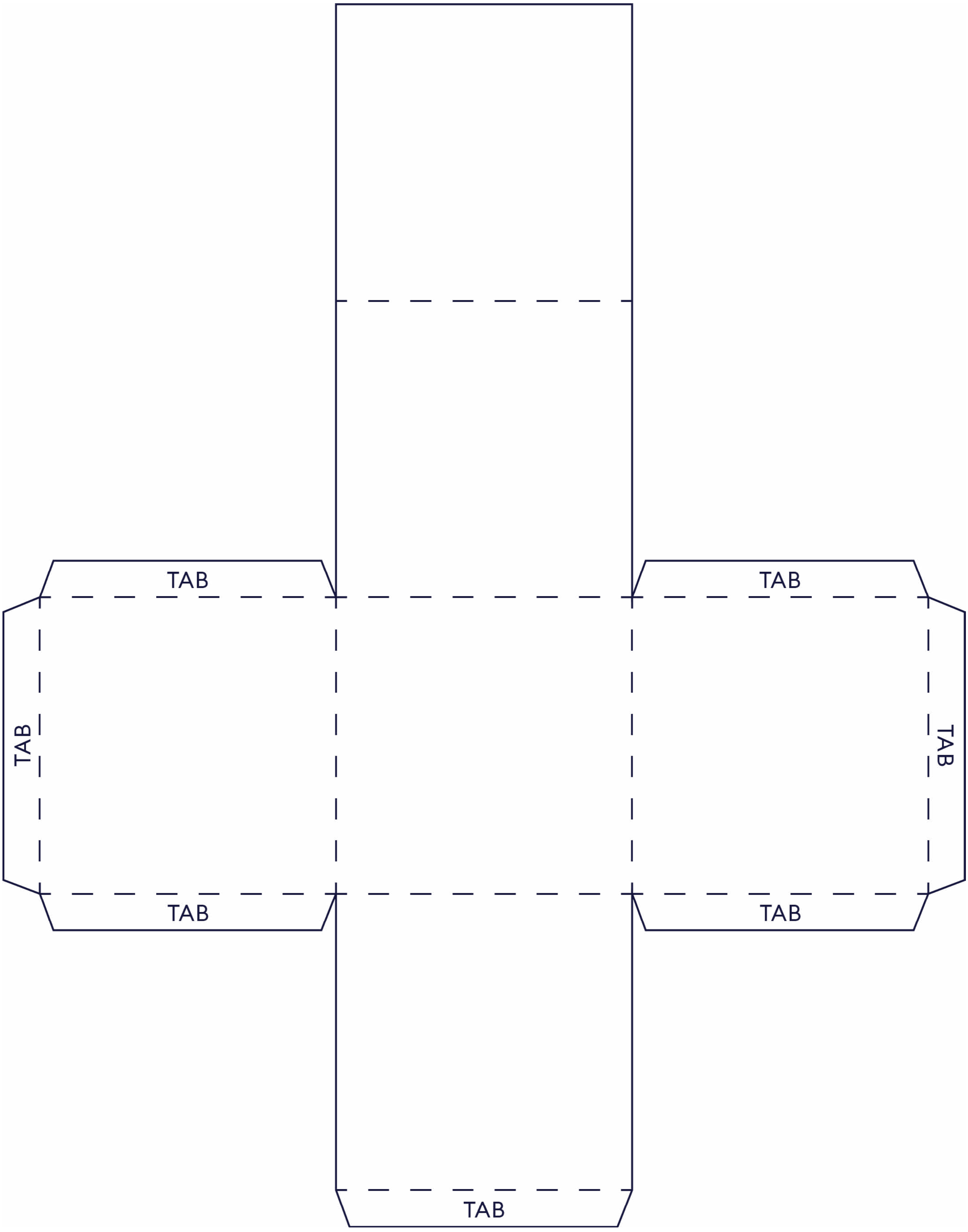
1. Using a ruler draw the net template onto a piece of light-coloured card.
2. Cut out the net and fold along the perforated lines.
3. Draw onto the net the features of a submersible, considering which panels are the front and back, the sides and the top and bottom. Decorate each panel accordingly.
4. Attach a loop of string to the middle of the back side of the roof of the submersible, using sticky tape.
5. Stick the net together using sticky tape or glue stick. Ensure the loop of string is at the top of the cube and can be used to lift the submersible.



Expected results

- Students will construct a cube which will act as their submersible when they test their machine.

ACTIVITY OVERVIEW 5b



Designing a crane

What is your crane going to look like? Sketch your ideas here and label the parts.

Look at the materials available to you. Decide what features will your crane have, and what you will use to make them. Then, draw or write your ideas in the boxes below.

Feature	What I will make it from	Why I have chosen this material

Changing ideas

Now you have started building your crane, have you made any changes to your original design? Explain your reasons here:

Evaluating and improving

Was your design successful? Explain why.

What could you do next time to make your crane even better?

Why is it important for scientists to understand how materials behave when designing structures?

Were there any problems during your build? If so, what happened?

How would you stop these happening next time?

How do you recover a submarine with levers and pulleys?

Age 7-11

60 minutes

Curriculum links

- Explain how machines can help us
- Use knowledge of materials to make suitable choices
- Plan, investigate, record and make conclusions

Resources

Slideshow 6:
How do you recover a submarine with levers and pulleys?

Activity Overview 6a:
Levers and pulleys

Student Sheet 6a:
Levers and pulleys

360 Video:
Submarine recovery

Subject Update:
How to: Quick start to 360 VR in the classroom

Subject Update:
How to: Four ways to use 360 VR in the classroom

Home learning

Explore how water pressure affects deep sea exploration and try the Under Pressure activity at www.encounteredu.com/discover/activities/under-pressure

Lesson overview

Part two sees students develop their understanding of levers and pulleys and relates this to how cranes launch and recover submersibles. Students will continue to develop their crane, this time adding a lever or pulley system which will raise and lower their submarine model. Students will reflect on their build, evaluate the effectiveness of their cranes and make suggestions for improvements. Finally, students will demonstrate their learning by creating a poster which describes and explains how cranes work to launch and recover submersibles, concluding the Submarine STEM unit.

Lesson steps	Learning outcomes
1. Levers and pulleys (10 mins) Students investigate how levers and pulleys work and how their cranes will use these to launch the submersible.	• Apply understanding of levers and pulleys
2. Plan and build (30 mins) Students plan and construct the levers and pulleys on their cranes and test their function using model submersibles.	• Construct a working model of a crane using levers and pulleys
3. Evaluate and improve (10 mins) In pairs students consider how effective their crane is through evaluation and make suggestions for improvements.	• Reflect on learning and suggest improvements
4. Demonstrate learning (10mins) Students design a poster which demonstrates how cranes launch and recover submersibles.	• Explain why cranes are used and how they work

Step	Guidance	Resources
1 10 mins	Step 1 introduces students to the learning outcomes. Students are then introduced to levers and pulleys and discuss their uses when launching and recovering submersibles. · Use slides to introduce lesson objectives. · Watch 360 Video: Submarine recovery, moving around the panorama to draw student's attention to the features of the launch vessel, crane and pulley system. · Show students slides 5-8. Explain how simple levers and pulleys work. Students discuss with a partner where you might see levers and pulleys in real life, such as scissors or window blinds. · Ask students how they could use levers and pulleys on their crane to help lift and manoeuvre their submersible. · Some adjustment in timing and support may be necessary here, to ensure students have a strong crane structure and a submersible model with which to test their crane in the following steps.	**Slideshow 6:** Slide 1-8 **360 Video:** Submarine recovery **Subject Update:** How to: Quick start to 360 VR in the classroom **Subject Update:** How to: Four ways to use 360 VR in the classroom
2 30 mins	Please refer to Submarine STEM 7-11 Lesson 5 resources for information and guidance on the first part of this activity. In step 2 students explore the different materials provided to practically examine how pulleys and levers work. · Hand out materials specified in Activity Overview 6a. · Allow students time to explore the materials and discuss with their partner what might be useful in making a lever or pulley system for their crane. · Once students have selected the materials they wish to use (they may come back for more / different materials later) they should plan their launch system by sketching and annotating Student Sheet 6a. · Instruct students to retrieve their cranes from Lesson 5 and begin constructing their lever or pulley system. · Explain that their ideas can be revised as they go along as they will be using trial and error to construct their pulley system. Therefore, making mistakes is useful to learn from and will improve their design. · Use Activity 6a to brief students and model ideas and concepts where necessary.	**Slideshow 6:** Slide 9 **Activity Overview 6a:** Levers and pulleys **Student Sheet 6a:** Levers and pulleys

Step	Guidance	Resources
3 10 mins	Step 3 asks students to evaluate their design and make suggestions for improvements. · Once students have completed their crane they should test it by attempting to raise and lower the submarine model. · Using Student Sheet 6a they can reflect on the effectiveness of their crane and whether it met the specification. · Ask students to reflect on what they would do differently and what improvements they could make. · Allow students time to look at other groups work and give constructive feedback. · If students require more time to complete their cranes steps 3 and 4 can be completed at another time. Students should all complete a crane with a lever and pulley and be able to explain how and why it works. · Take photographs of the students during construction and on completion.	**Slideshow 6:** Slide 10 **Student Sheet 6a:** Levers and pulleys
4 10 mins	Step 4 asks students to design a poster which demonstrates how cranes are used to launch and recover submersibles. · Explain that students should design a poster which includes drawings, labels and information about how submersibles are launched and recovered. · The poster should include information about the structure of cranes and how levers and pulleys work. · Review learning outcomes with a show of hands. · Display slide 13 to conclude the Submarine STEM unit. · If more time is required to complete the build, the poster can be set or completed for homework.	**Slideshow 6:** Slides 11-13
H/L 15 mins	· Explore more of Submarine STEM on the Encounter Edu website. Check out how water pressure effects deep sea exploration at www.encounteredu.com/discover/activities/submarine-engineer and try the Under Pressure activity at www.encounteredu.com/discover/activities/under-pressure.	**Slideshow:** Slide 14 **Activity:** Under pressure **Activity:** Submarine engineer

Levers and pulleys

Age 7-11
(adult supervision)

30 minutes

Resources

What you need

- Completed work from Lesson 5 and home learning
- Cardboard - 20 cm x 20 cm. 1 per group
- Scissors
- Sticky tape
- String
- Paperclips
- 20cm lengths of wooden dowel (6mm diameter) - 1 per group

Safety and Guidance

Precautions

Students will be using scissors to cut and possibly other sharp implements. Great care should be taken to avoid injury, demonstrate how to make holes in cardboard safely, use cutting mats where possible.

Overview

In this activity students add a lever or pulley system to their crane, capable of raising and lowering their submarine model.

Running the Activity

1. Students cut out two circles of cardboard 4cm in diameter. Using a sharp tool make a hole in the centre of the circle around 1cm in diameter.
2. Take a piece of card (8cm x 3cm) and roll into a tube, stick in position. The tubes diameter should be around 1cm.
3. Insert the tube into one cardboard circle and then the other, space the cardboard circles 4cm apart. 1 cm of tube should protrude from each end. Make four cuts 1cm deep into each end of the tube, bend them flat against the cardboard circles and sticky-tape them into position making sure the hole in the tube is clear. This is your bobbin.
4. Towards the back of the shoe box make a H shaped incision. Fold the flaps up. Make a hole in each flap big enough to poke a piece of dowel through
5. Take a piece of dowel and slide the bobbin on, then pass through the holes in the flaps you have just cut. By turning this piece of dowel your bobbin should rotate. If it does not have enough friction, students may insert more card into the central tube to give it adequate friction.
6. Students now take a long piece of string and sticky tape one end to the middle of the bobbin. Use the handle to wind a few loops of string around the axie. Run the length of string over the top piece of dowel on the crane. Let the string drop into the 'water'.
7. Take a paper clip and carefully unbend the lower part and reshape into a hook. Tie the other end of the string through the top loop of the paper clip.
8. Test turning the handle to lengthen and shorten the piece of string. Students can now put the hook through the loop on their submersible model and attempt to raise and lower it into the water.

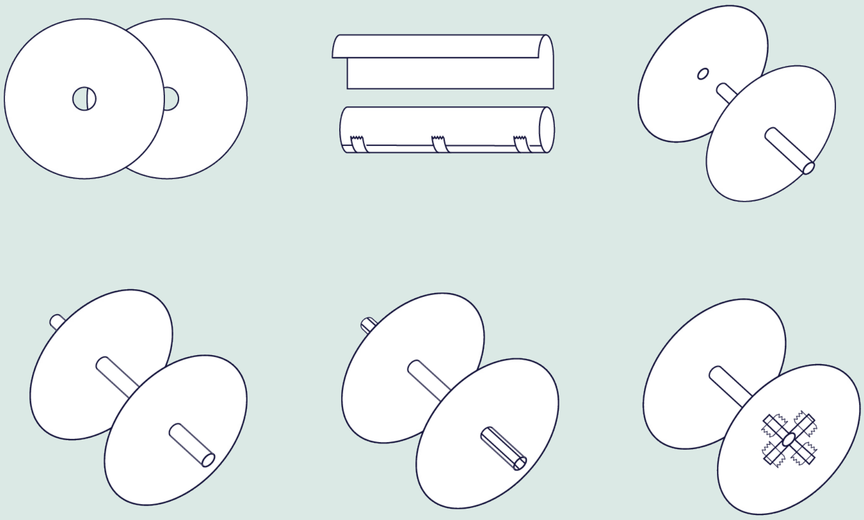
Expected results

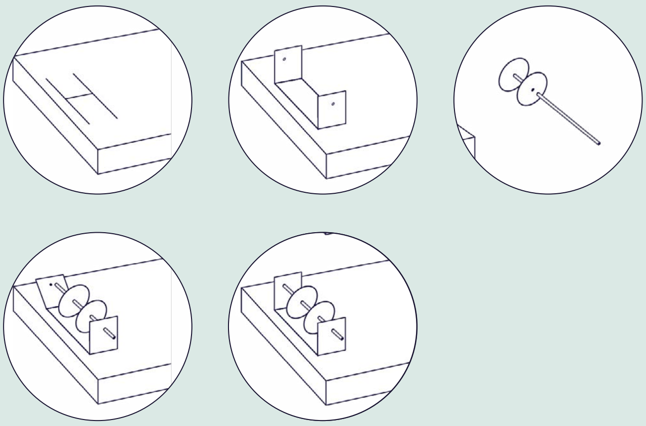
- Students will make a working pulley system to raise and lower their submersible.

ACTIVITY OVERVIEW 6a

Running the Activity

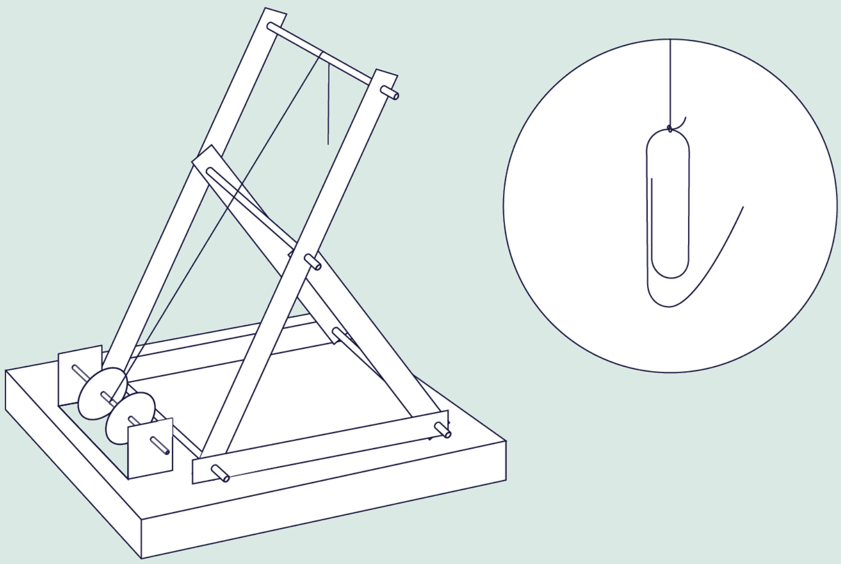
1. Students cut out two circles of cardboard 4cm in diameter. Using a sharp tool make a hole in the centre of the circle around 1cm in diameter.
2. Take a piece of card (8cm x 3cm) and roll into a tube, stick in position. The tubes diameter should be around 1cm.
3. Insert the tube into one cardboard circle and then the other, space the cardboard circles 4cm apart. 1 cm of tube should protrude from each end. Make four 1cm deep cuts into each end of the tube, bend them flat against the cardboard circles and sticky-tape them into position making sure the hole in the tube is clear. This is your bobbin.





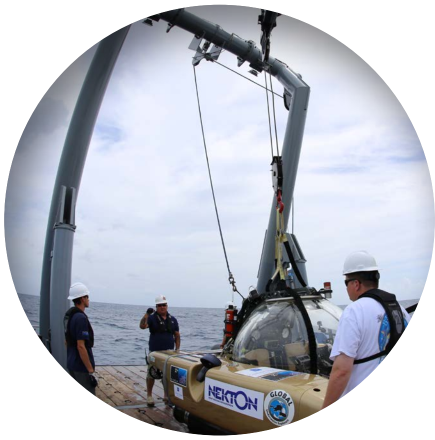
4. Towards the back of the shoe box make a H shaped incision. Fold the flaps up. Make a hole in each flap big enough to poke a piece of dowel through
5. Take a piece of dowel and slide the bobbin on, then pass through the holes in the flaps you have just cut. By turning this piece of dowel your bobbin should rotate. If it does not have enough friction, students may insert more card into the central tube to give it adequate friction.

6. Students now take a long piece of string and sticky tape one end to the middle of the bobbin. Use the handle to wind a few loops of string around the axie. Run the length of string over the top piece of dowel on the crane. Let the string drop into the 'water'.
7. Take a paper clip and carefully unbend the lower part and reshape into a hook. Tie the other end of the string through the top loop of the paper clip.
8. Test turning the handle to lengthen and shorten the piece of string. Students can now put the hook through the loop on their submersible model and attempt to raise and lower it into the water.



STUDENT SHEET 6a

Levers and pulleys



How will you add a lever or pulley system to your crane? Sketch your ideas here and label the parts.

Look at the materials available to you. Decide how you will construct a lever or pulley system and what you will use to make them. Then, draw or write your ideas in the boxes below.

Lifting cable		
Pulley		

STUDENT SHEET 6a

Pivot		

Changing ideas

Have you made any changes to your original design? Explain your reasons here:

Evaluating and improving

Was your design successful? Explain why.

Were there any problems during your build? If so, what happened?

How would you stop these happening next time?