High and dry
Protecting objects on a floating platform
Ocean Engineering
Floating and Sinking
Unit for pupils from 9-12 years

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Introduction

This is one of ten ENGINEER primary school units developed to support science learning within the context of a wide range of engineering design challenges. Based on the successful Boston Museum of Science *Engineering is Elementary* model of inquiry-based learning, each unit features a different science area and engineering field and requires only inexpensive materials in order to support pupil-led science exploration and problem-solving design. The units have been developed to appeal to a wide range of pupils and to challenge stereotypes of engineering and engineers and so enhance both boys' *and* girls' participation in science, technology and engineering.

Our pedagogic approach

Central to each unit is the engineering design cycle: ask, imagine, plan, create, improve. Emphasizing the cycle helps teachers to foster pupils' questioning and creativity, and gives space for pupils to develop their problem-solving skills including testing alternative options, interpreting results and evaluating their solutions. Tasks and challenges have been designed to be as open-ended as possible, and to avoid 'right answers'; in particular, the unit developers have aimed to avoid competition which may alienate some pupils, while retaining the motivation of wanting to solve a problem. An important goal of all of the units is to maximise opportunities for group work and to support pupils in learning to work together and communicate their ideas effectively. Students need to discuss their ideas as they explore a new problem, work out what they need to know and share their findings, design solutions, and then improvements.

How the units are organised

Each unit begins with Lesson 0, a general preparatory lesson which is common to all ten units. Teachers choosing to use more than one unit will want to start with this lesson the first time they use the units and begin at Lesson 1 in subsequent units. Lesson 1 introduces a story context or problem which drives what happens next: Lesson 2 focuses on what exploring the science that the pupils need to solve the problem, while in Lesson 3 they design and build their design solution. Finally, Lesson 4 is an opportunity to evaluate, present, and discuss what they have done.
Each unit is, however, unique, and some units are more demanding in terms of science understanding and the length of time required for the unit varies. Likely timings and age targets are indicated in each unit overview. Units have been designed to be flexible, however – teachers can choose which activities they want to include, and there are options for differentiating activities to cater for a range of abilities.

Teacher support

Each unit guide has been written to provide appropriate science, technical and pedagogic support for teachers with a wide range of experience and expertise. Each lesson includes suggestions and tips for supporting inquiry-based learning, classroom organisation and preparation. Science and making activities are illustrated with photographs. Science pedagogy notes in the Appendix explain and discuss the science involved in the unit and how to support understanding of the central concepts for pupils in the age range. Worksheets which can be copied and answer keys are also provided.

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Index

Introduction **2**
Overview of the unit **5**
Lesson 0 – Engineering an envelope **11**
0.1 Introduction - 10 minutes - small group and whole class discussion 12
0.2 Activity 1 What is an envelope? - 5 minutes, small groups 12
0.3 Activity 2 Matching envelopes to objects - 15 minutes - small groups and whole class discussion 13
0.4 Extension work - optional - 10-30 minutes - small groups 13
0.5 Conclusion – 10 minutes - whole class discussion 14
0.6 Learning outcomes - for optional assessment 15
Lesson 1 – What is the engineering problem? **16**
1.1 Introductory activity – setting the Problem – working in groups - 30 minutes 17
1.2 Floating or Sinking – experimenting in groups – 45 minutes 17
1.3 Conclusion – plenary -15 minutes 18
Lesson 2 – What do we need to know? **19**
2.1 Introductory activity – starting an investigation – working in groups-discussion - 30 minutes 20
2.2 Reveal the force of buoyancy – experimenting in groups – 10 minutes 20
2.3 Buoyancy - volume (size), an Inseparable Relation – experimenting in groups – 10 minutes 21
2.4 Changing the Weight –Experimenting in groups - 15 minutes 22
2.5 Changing the volume (size) – experimenting in groups - 15 minutes 22
2.6 Explain your observation – experimenting - 10 minutes 23
2.7 Conclusion – plenary - 30 minutes 23
Lesson 3 – Let's build! **25**
3.1 Introductory activity – working in groups - discussion - 15 minutes 26
3.2 Ask-Activity 2 – discussion - working in groups –10 minutes 26
3.3 Imagine-Activity 3 – working in groups - 10 minutes 27
3.4 Plan-Activity 4 – working in groups - 10 minutes 27
3.5 Create-Activity 5 – working in groups - 75 minutes 27
3.6 Improve- Activity 6 – working in groups - 45 minutes 28
3.7 Conclusion – plenary - 10 minutes 28
Lesson 4 – How did we do? **29**
4.1 Introductory activity – review EDP Steps – discussion-working in groups - 30 minutes 30
4.2 Present your work – working in groups –60minutes 30
4.3 Conclusion – plenary - 15 minutes 30
Appendices **31**
Story to set the context *31*
Engineering design cycle *32*
Worksheets and answer sheets *33*
Worksheet 1 Lesson 0 – Engineering? 34
Worksheet 1 Lesson 0 - Engineering? – Teacher notes 35
Worksheet 1 Lesson 1- Setting the problem 36
Worksheet 2 Lesson 1- Floating or Sinking? 37
Worksheet 3 Lesson 1- Conclusion! 38
Worksheet 1 Lesson 2 – Starting an investigation 39
Worksheet 2 Lesson 2 – Exploring the force of buoyancy 40
Worksheet 3 Lesson 2 – Buoyancy - Volume (Size). An Inseparable Relation 42
Worksheet 4 Lesson 2 – Changing the Weight 43
Worksheet 5 Lesson 2 – Changing the Volume (Size) 44
Worksheet 6 Lesson 2 – Explain your observation 45

Worksheet 7 Lesson 2 – Conclusion 46
Answer sheet Worksheet 1 Lesson 2 - Starting an investigation 47
Answer sheet Worksheet 2 Lesson 2 – Reveal the force of buoyancy 48
Answer Sheet Worksheet 3 Lesson 2 – Buoyancy - Volume (Size) An Inseparable Relation 50
Answer Sheet Worksheet 4 Lesson 2 – Changing the Weight 51
Answer Sheet Worksheet 5 Lesson 2 – Changing the Volume (Size) 52
Answer sheet Worksheet 6 Lesson 2 – Explain your observation 53
Answer sheet Worksheet 7 Lesson 2 – Conclusion Weight – Size Relation 54
Worksheet 1 Lesson 3- Engineer Design Process 55
Answer sheet Worksheet 1 Lesson 3- EDP 58
Worksheet 1 Lesson 4- Present Your Work 59
Instructions Sheet 60
Pictures for Lesson 4 – Conclusion Activity 63
Assessment Sheet - Lesson One 65
Answers - Assessment Sheet for Lesson One 67
Answers - Assessment Sheet for Lesson Two 73
Assessment Sheet – Lesson 3 76
Answers - Assessment Sheet for Lesson Three 77
Assessment Sheet – Lesson Four 79
Science notes for teachers about buoyancy – sinking and floating 83
Some pupils' ideas of science concepts about sinking and floating 86
A Glossary of terms related to this unit 89
Partners 91

Overview of the unit

Duration: 8 hours and 30 minutes

Target group: 9-12 year old pupils

Description: This unit is an interesting and challenging way for the pupils to develop their knowledge about sinking and floating and to be introduced to the field of ocean engineering. By participating in the challenge **"Design your own floating platform",** the pupils will design, build and test a floating platform in order to transport items across the water. In order to achieve this, they will use the scientific principle of balancing forces, more specifically of buoyancy and weight and will get acquainted with the science investigation process.

Science curriculum: this unit will relate to the science curriculum for **forces**.

Engineering field: this unit introduces the field of ocean engineering

Objectives, in this unit the pupils will learn

- to observe and describe how different objects behave when placed into water;
- that there are two forces that act on an object (weight and buoyancy) which is immersed into water;
- the factors affecting sinking/floating of an object in water;
- to define the variables of the problem, make predictions and test them;
- to apply the Engineering Design Process (EDP) in order to solve a problem and make wider links with science and engineering;
- to self-evaluate, reflect on their work and finally present it in front of an audience.

The lessons in this unit:

A **Preparatory lesson** aims at raising awareness of how engineering contributes to our daily lives in ways that are not always obvious.

Lesson 1 introduces the engineering problem, its context and the engineering design process (EDP).

In Lesson 2, the 'ask' element of the engineering process leads to an investigation of **sinking and floating**.

Lesson 3 involves the pupils in applying the engineering design process (EDP) to meet the challenge. The challenge is **Design your own floating platform**.

In Lesson 4, it's time to reflect and evaluate the process of creating the **floating platform**. This is also the moment for pupils to present their work in front of an audience, to show if they are able to meet all the criteria, to talk about how they made improvements and make wider links between science and engineering.

Tip – The teacher should bear in mind that during the whole process, pupils (or the teacher) could take photos that will be used in the poster presentation in the activity within Lesson Four.

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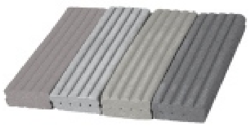
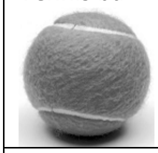
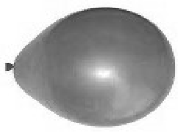
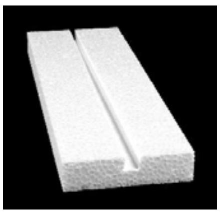
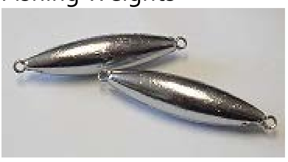
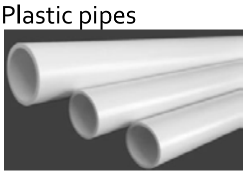
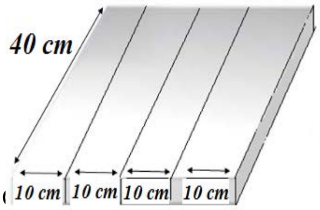
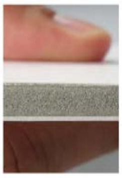
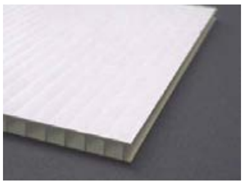
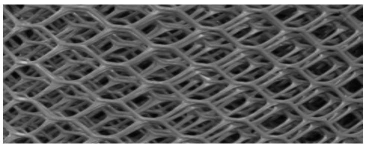
Resources

List with all the materials and quantities needed for 30 pupils (6 groups of 5 pupils each).

Material	**Total amount**	**Lesson 0**	**Lesson 1**	**Lesson 2**	**Lesson 3**	**Lesson 4**
Soft Drink Can 	6		6			
Plastic box with paper clips 	6		6			
Spherical Candle 	6		6			
Cork Stopper 	6		6			
Plasticine –Modelling Clay 	6		6			
Tennis ball 	6		6			
Balloon 	12		6			
Piece of Styrofoam 	6		6			

Material	Total amount	Lesson 0	Lesson 1	Lesson 2	Lesson 3	Lesson 4
Piece of wood 	6		6			
Milk can 	6		6			
Shampoo 	6		6			
Small rock 	6		6			
Thin bar of soap 	6		6			
Bucket 	6		6	6		
Dynamometer 10N (or 1 Kg) 	6			6		
Pump for balloons 	6			6		
Balloons (medium or large size) 	12			6		
Paper napkins	6			6		

						
Material	**Total amount**	**Lesson 0**	**Lesson 1**	**Lesson 2**	**Lesson 3**	**Lesson 4**
Baking Soda 	1 vase			6 spoons		
Marbles 	150			6 sets of 25 marbles per group		
Plastic spoons (for the baking soda) 	6			6		
Fishing Weights 	24			6 sets of 4weights (e.g. 50 g, 100g, 250 g, 500 g)		
Plastic cylindrical box (e.g. toothpick box) 	6			1 box per group		
Empty milk or water bottles (1 Lt) 	12				2 bottles per group	
Styrofoam cups (330-350 ml) 	180				30 cups per group	
Plastic pipes 	36				1set of 6 plastic pipes per group	

Material	**Total amount**	**Lesson 0**	**Lesson 1**	**Lesson 2**	**Lesson 3**	**Lesson 4**
Mount-board (40 x 40 cm) (cut into 4 pieces 40 cm x 10 cm each)   pieces 40 cm x 10 cm each) 	24				1 set of 4 pieces per group	
Duct tape 	6				6	
Plastic net (40 x 40 cm) 	6				6	
Fishing line (or thin rope)  	6				6	
Scissors 	6				6	
Zip Ties (aka Tie Wraps) 	240				1 set of 40 Tie Wraps per group	
Pencils 	6				6	

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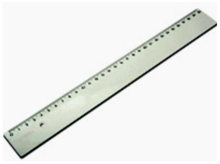
Material	**Total amount**	**Lesson 0**	**Lesson 1**	**Lesson 2**	**Lesson 3**	**Lesson 4**
Permanent marker 	6				6	
Ruler (40 cm) 	**6**				6	
Plastic tank 0.5 – 1 m^3 (for testing the floating platform) 	**1**				1	
Screwdrivers 	**6**				6	
PVC Pipe cutter (if needed) 	**1**				1	
Coloured markers	**6**					6
Paper block for flipchart	**1**					1
Flipchart 	**1**					1

Lesson 0 – Engineering an envelope
What is engineering?

Duration: teachers can choose how long to spend on this lesson depending on how much experience pupils already have. The introduction, main activities and conclusion will take up to 40 minutes; additional extension work can add a further 10-30 minutes.

Objectives, in this lesson pupils will learn that:

- engineers design solutions to problems using a range of technologies;
- technologies that are appropriate for a particular problem depend on the context and materials available;
- made objects have been engineered to solve problems;
- engineers can be men or women.

Resources (for 30 pupils)

- 8 'post-it' notes packs
- 8 sets of at least 5 different envelope types
- 8 sets of at least 5 different objects
- 8 sets of packaging examples for optional extension work
- Card, paper, glue, scissors for optional extension work

Preparation

- Collect together a range of different envelopes and packages
- Print copies of worksheet 1 if using
- Collect pictures for introductory activity

Working method

- Small groups
- Whole class discussion

Context and background

This lesson is the same in all units and is intended to encourage thinking about what technology is and to challenge stereotypes about engineers (particularly those associated with gender) and engineering.

It aims to develop the understanding that objects in the made world are designed for a purpose and that technology in its broadest sense refers to any object, system or process that has been designed and modified to address a particular problem or need.

Pupils can think about this by discussing what problem the technology of a particular artefact (in this case an envelope) is intended to solve. In this lesson, they discuss the range of technologies that are used to engineer an envelope for a particular intended purpose.

The lesson is also intended to avoid value judgments of ' high tech' versus 'low tech' and to encourage pupils to appreciate that it is appropriate technology in a particular context that is important: the range of available materials will determine the technology that the engineer applies to solving the problem.

0.1 Introduction - 10 minutes - small group and whole class discussion

Divide the class into groups of 4 and provide a packet of 'post-its' for each group. Ask the groups to discuss all the things they associate with the terms 'engineering' and 'technology'. Ensure that, as part of the discussion, each individual within the group puts at least one idea on a 'post it'.

Invite each group to place their 'post its' on to a master display sheet and briefly explain their choices to the rest of the class. Keep the whole class list for review at the end of the lesson.

Additional support for discussion

This part of the lesson can be extended by providing pictures of stereotypical and unusual examples of engineering and asking pupils to group the pictures into those that they associate with engineering and those that they do not. You could use Worksheet 1 for this activity, or use the pictures there as a whole class display. Ask pupils to work in pairs to decide which of the pictures they think are related to engineering and to give their reasons why they think that some are and some are not. Each pair of pupils could share their ideas with another pair and discuss similarities and differences in ideas. You could use these ideas as a basis for a whole class discussion; encourage pupils to open up their thinking about what counts as engineering and who could be involved in it.

0.2 Activity 1 What is an envelope? - 5 minutes, small groups

Organise pupils into small groups to discuss what an envelope is and what counts as an envelope. To help discussion, provide a range of examples which cover and/or protect objects or materials for particular purposes (as in the pictures).

An important part of this activity is to encourage pupils to notice that there are many interpretations of the idea of an envelope. In the pictures there are some examples that might challenge their idea of an envelope: they include a broader interpretation of what an envelope is as something that 'houses', 'protects', 'holds in place', 'covers', 'hides' or even 'reveals' a range of different objects.

0.3 Activity 2 Matching envelopes to objects - 15 minutes - small groups and whole class discussion

Divide the class into groups of 4 and provide a range of 'envelopes' and objects that could go in them. Ask the pupils to select which envelopes would be most suitable for the objects and to explain why.

The objects could include: a pair of spectacles; a certificate or photograph that must not be bent; a delicate piece of jewellery; a returnable DVD; a set of confidential papers; a pair of scissors. The range of objects and envelopes can be varied according to context and what you have available.

The following questions can help guide the discussion:

- What material is the envelope made from?
- What fixings and fastenings are used in the envelope?
- What range or types of objects could the envelope be used for?
- What other materials it could be made from?

Each group should report their ideas back to the class.

There is an opportunity here for the teacher to lead the discussion and talk about the various technologies used in each engineered envelope including the types of structures, fixings and fastenings used (e.g. reusable or permanent fixings; reinforcement areas; internal and external materials selected; how edges are sealed.)
This is an evaluative activity and could be related back to the engineering design process: discussion could include thinking about the process that engineers need to be involved in when making something to solve a particular problem.

0.4 Extension work - optional - 10-30 minutes - small groups

1. Present pupils with a range of envelopes and ask them to evaluate their design in terms of their fitness for purpose (see picture).

Envelopes could be compared in terms of the types of fastenings and reinforcements used, and the mix of different materials used (e.g. bubble wrap, absorbency, strength- i.e. resistance to tearing).
This activity could be extended to looking at different types of packaging in relation to net folds and how these are used to reduce (or eliminate) the need for adhesives in the manufacturing process. The following 3 pictures demonstrate packaging that does not use any form of adhesive; the making involves only one type of material using cuts and folds for fastenings.

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2. Organise pupils into small groups to design and/or make an envelope in order to deliver a particular chosen object. Groups will need to draw on their understanding of materials and the design making process to produce a range of alternative designs. These could then be evaluated in whole class discussion.

0.5 Conclusion – 10 minutes - whole class discussion

Lead a plenary discussion drawing on the original class 'post its' (and where appropriate their groupings of the 'engineering' photographs), reminding the pupils of how their original thinking might now have changed. Ask pupils to reflect on what an engineer does and what technology is.

- Emphasise that most things we use are made for a purpose and that engineers use a range of skills in finding solutions to problems.
- This involves thinking about solutions to solve problems; some of these work and some are less successful – the engineering design process includes evaluation and improvement.
- It is not 'high' tech or 'low' tech but *appropriate* technology that matters - engineers need to consider their context and resources.
- There are many types of engineering, and many different types of people from across the world, and both men and women, are engineers.

There might be a range of equally acceptable definitions for the terms 'engineer' and 'technology'; these terms are often used interchangeably, e.g. engineering could be considered as the use of technology for problem solving. In talking about the relationship between *engineering, science and technology, pupils can be encouraged to think about how engineers, in the process of making objects to solve problems, use a range of technologies (including fixings and fastenings, various types of materials and different components in a range of systems) and a range of science understandings. This is an opportunity to open up discussion about how things are made and by who, and what is involved in the process of thinking about solutions to problems.*

0.6 Learning outcomes - for optional assessment

At the end of this lesson pupils should be able to**:**

- Recognise how a range of systems, mechanisms, structures, fixings and fastenings are used in artefacts in different ways to provide a range of solutions to solve problems
- Understand that appropriate technology is often dependent on the context and materials available
- Recognise that engineers use a wide range of skills in developing solutions to problems
- Recognise that many different types of people with different interests and skills can be engineers

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Lesson 1 – What is the engineering problem?
Finding out about the challenge

Duration: about 90 minutes

Objectives, in this lesson the pupils will learn

- to observe and describe how different objects behave when placed into water;
- to organize and classify their observations;
- to be familiar with the **"Ask" element** of the EDP.

Resources (for 30 pupils - six groups of 5 pupils each)

- ☐ 6 Soft drinks
- ☐ 6 Paper clips
- ☐ 6 Plastic boxes half full of paper clips
- ☐ 6 Candles in shape of a ball or a big cylinder
- ☐ 6 Cork stoppers
- ☐ 6 Plasticine
- ☐ 6 Milk cans
- ☐ 6 Small rocks
- ☐ 6 Buckets
- ☐ 6 Tennis Balls
- ☐ 6 Balloons
- ☐ 6 pieces o f Styrofoam
- ☐ 6 pieces of wood
- ☐ 6 Bottles of water
- ☐ 6 Shampoos
- ☐ 6 Oranges (and the orange without the peel)
- ☐ 6 thin bars of soap

Preparation

- Collecting and organizing the materials
- Fill the buckets with water
- Photocopy the lesson 1 Worksheets

Working method

- Working in groups
- Experimenting in groups
- Plenary

Key ideas in this lesson

- Ask element of EDP
- Prediction, Observation and Classification
- Questioning weight as the main factor in sinking or floating

Context and background

In this *lesson, the context of the engineering problem is set and the Engineer Design Process (EDP) is briefly introduced for the first time. As the lesson progresses, the pupils discuss with their teacher the materials that are appropriate for their engineering problem. Then pupils predict, test and observe the behaviour of some materials when placed in the water (floating or sinking). In addition, pupils begin to organize and classify their observational data. In that way pupils are practically getting in touch, for the first time, with the 1st step of the Engineering Design Process (the **"Ask" element**). Finally, pupils start to think about what they really need to know (which is the core of Lesson Two) in order respond to the engineering challenge.*

1.1 Introductory activity – setting the Problem – working in groups - 30 minutes

The teacher briefly introduces the general subject by reading the Engineering Challenge Story (**see appendix 1**)**.** The teacher then states that engineers who deal with problems such as the one we are facing here are called ocean engineers and that in the whole unit we are going to act as ocean engineers. Now it is the time for the teacher to introduce the field of ocean engineering and the EDP to the pupils. Ocean engineering broadly refers to the engineering involved in solving problems in marine environments and designing and developing constructions such as rigs, platforms and any other marine structures or equipment. In order to do this, an ocean engineer applies his/her knowledge of physics, mechanical and electrical engineering by following the process of 5 steps, called the Engineering Design Process. At this point the teacher briefly introduces the EDP to the pupils for the first time. The teacher draws the circle of the EDP (see **appendices**) on the board and mentions the 5 steps of the process by describing, in a few words, what each step is about. A short description of each step follows.

1) **Ask** appropriate questions concerning the problem,

2) **Imagine** possible solutions,

3) **Plan** carefully how to implement one of your ideas or combine a bunch of your ideas into one design,

4) **Create** your design and test if it meets your criteria,

5) **Improve** your design and make it even better; test it again.

The pupils are then divided into groups of 4 or 5 pupils, preferably mixed gender and aptitude. The teacher prompts each group to begin working on the challenge by drafting a list of materials and why they think are suitable for constructing their floating platform. The teacher asks each group to present their list and explain their choices, and provokes discussion among groups about possible common properties or differences between the materials that they proposed (**Worksheet 1 Lesson 1**). The teacher's goal is to introduce the pupils to the **"Ask" element** of the EDP and motivate them to start thinking about possible solutions to the engineering problem.

Tip – Pupil teams should remain the same in every Lesson of the Unit. Also, it might be more engaging if pupils give a name to their team.

Tip – The pupils are reminded of the Engineering Design Process, and this is fully performed by them, in lesson 3. In lesson 1, the aim is just to get the pupils in touch with EDP for the first time. So the teacher should not spend too much time on this.

1.2 Floating or Sinking – experimenting in groups – 45 minutes

Pupils experiment with placing different types of objects in a tank full of water. The steps of the activity are described below.

- The teacher introduces and links the activity "Floating or Sinking" which involves placing objects in a bucket full of water to the previous discussion with the pupils about the appropriate materials for the floating platform. In order to do this the teacher asks the pupils to look at the, "***What do we need***" list in ***Worksheet 2 Lesson 1.*** Then the teacher asks them to check if any of the objects they proposed for the platform are included in the provided objects, or appear to have similar properties (in terms of weight, volume or shape) with some of them. The teacher then suggests that the pupils should place each one of them in the bucket and observe whether they float or sink and afterwards fill in the data table (***Table 1.1 from Worksheet 2 Lesson 1***). The teacher should also point out that pupils are asked to make their predictions about which will sink or float and record them in Table 1.1, before placing different objects in the bucket. The pupils complete the data table (***Table 1.1.***) at the end of the activity and then check whether their predictions were right or wrong.

1.3 Conclusion – plenary -15 minutes

At the end of the activity "Floating or Sinking", the teacher asks pupil teams to classify the objects, filling in **Table 1.2 of Worksheet 3 Lesson 1,** using as the criterion sinking or floating. Then, the teacher encourages the pupils to reflect on their beliefs about floatation of the materials before and after their experiments. What goes next is a discussion between the teacher and the pupil groups about what kind of similarities the objects share which appear to float and in which ways they differ from the sinking ones.

Tip – The teacher should bear in mind that the similarity between the objects that floated is that all of them had small weight for their size. On the contrary, the objects that sunk had large weight for their size. However, the science concepts concerning sinking and floating will be thoroughly investigated in Lesson 2.

The **key teaching point** of the first lesson is that pupils begin to question their belief that weight is the only factor that affects sinking and floating. By the end of Lesson 1 the pupils are expected to start questioning the effect of weight on floating/sinking. By using focused questions, the teacher motivates the pupils to start thinking about the different factors affecting the floatation of an object in water.

e.g. "If weight is not the only factor that affects sinking or floating, what other factor/s do you believe play an important role? "

At this point, so that the pupils start to identify the steps of the EDP and connect those steps with their work, the teacher could ask the class:

"Looking back at what you have done during this lesson, do you identify any step of the EDP?"

Eventually, in this way, the teacher leads the pupils to the process of science investigation in Lesson 2 and which provides them with the necessary scientific knowledge they need in order to solve the engineering problem they face.

Lesson 2 – What do we need to know?
Finding out about sinking and floating as well as ocean engineering

Duration: 120 minutes

Objectives: in this lesson the pupils will learn

- That there are two forces acting on an object which is immersed into water. These forces are weight (gravity) and an up thrust force called buoyancy.
- That there is a certain condition, which must be met so that an object can float (buoyancy = weight) which means that these forces are in balance.
- To apply science investigation methods and processes.

Resources for 30 pupils – six groups of five pupils each

- 6 buckets
- 6 dynamometers *also known as spring balance*, (scale: 10Newton/1kg both indications)
- 24 fishing weights of different masses (50 g, 100 g, 250 g, 400 g) – 4 fishing weights per group.
- 30 balloons (1 balloon per pupil)
- Baking Soda
- Paper napkins
- 6 pumps for balloons
- 6 plastic spoons
- 6 small plastic boxes (toothpick box) and glass marbles (the number of marbles must be enough so that the plastic box will be full).
- 6 sets of Activities Worksheets

Preparation

- Teacher needs about 45 min for preparation
- Buckets filled with water.
- Materials for every activity should be distributed to each working group.
- Photocopying the lesson 2 worksheets.

Working method

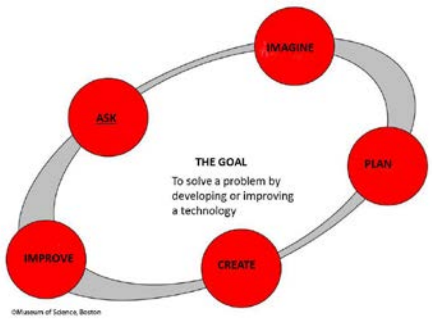
- Working in groups
- Experimenting in groups
- Plenary

Key ideas in this lesson

- Buoyancy
- Floatation
- Science Investigation Process - Predicting, Experimenting, Observing, Recording Data, Reaching Conclusions

Context and background

The purpose of this lesson is to get the pupils in touch with the science investigation process. Pupils start to think about what they need to know in order to solve the engineering problem (the ***"Ask" element*** *which is initially introduced in Lesson One). Pupils come up with investigative questions for which they try to find the answers by conducting controlled experiments, collecting and analysing their data. Through this process, pupils are guided to acquire the necessary scientific knowledge in order to design and construct the floating platform.*



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2.1 Introductory activity – starting an investigation – working in groups-discussion - 30 minutes

The teacher briefly reviews Lesson One, reminding the pupils about the engineering problem they face- to design a floating platform capable of transporting items. The teacher also points out the conclusion the pupils reached through the activity "Floating or Sinking" in Lesson One that floating or sinking is not just a matter of an object's weight). A question should be raised here by the teacher: ***"Some objects that are heavier than others float, while the less heavy sink. Why do you think this happens?"*** Pupils should then be encouraged to propose questions they need to answer in order to solve their engineering problem. **Worksheet 1 of Lesson 2** asks them to note down their questions The teacher then discusses with the pupils to help them decide which of the questions they proposed are the most central to investigate because they will help with solutions. The main aim here is to encourage the pupils to ask investigative questions.

The key questions which are important to investigate and are the focus for the activity are:

- **What prevents an object that floats from moving towards the bottom of the sea?**
- **Does water exert force on any objects we immerse in it? If so, on what does this force depend?**
- **Is there a relationship between the weight of an object and its volume (size) so that the object can float?**

Tip - The word "size" can be used instead of "volume" in cases where the concept of volume is not in the curriculum. It needs to be clear, however, that an object's volume is a fixed physical quantity whereas its size is a subjective concept.

Once the pupils and the teacher have decided about the most suitable questions, they begin to investigate them with the help of the teacher. The investigation of a question such as the third one, is an especially good opportunity for the teacher to tell the pupils that a part of every science investigation process is the determination of the independent and dependent variables of the investigation. The independent variable is typically the variable representing the value being manipulated or changed (e.g. weight or volume) while the dependent variable is the observed result (e.g. sink or float) of the independent variable being manipulated. It is expected that the pupils will propose a number of variables affecting the observed result to any investigational question they put forward (**see *Table 2.1. of Worksheet 1 Lesson 2***). In that way, the teacher may highlight the misconceptions that the pupils usually have about sinking/floating. Finally, the teacher asks the pupils to tell how they can check whether their predictions are right or wrong. In that way, the teacher introduces the pupils to the activities 2.2 – 2.6 .

2.2 Reveal the force of buoyancy – experimenting in groups – 10 minutes

Pupils use a dynamometer to weigh four different fishing weights outside and within water. The teacher provides each team with a dynamometer and four fishing weights of different masses. The teacher then encourages the teams to weigh the objects outside the water and note down the readings from the dynamometer. The pupils are asked if the indications will be the same as in the first set of experiments if they now weigh the objects in the water.

After that, pupil teams weigh the objects within the water tank and note down the readings from the dynamometer. At the end of the experiment, pupil should be asked to explain the nature of the different readings of the dynamometer - **Worksheet 2 in Lesson 2 and Table 2.2**. for keeping records of this experiment.

Tip - The indication of the dynamometer will be smaller when the objects are immersed in the water.This can happen only if an upward force is exerted on the object from the water (buoyant force). In both experiments we have a downward pull exerted on the dynamometer's spring by the object's gravity (weight). However, in the second experiment, we also have an upward push exerted from the water to the object (buoyancy). This will be clearer in the following experiment.

2.3 Buoyancy - volume (size), an Inseparable Relation – experimenting in groups – 10 minutes

Pupils try to push an inflated balloon into the water tank.

The teacher provides each pupil team with balloons. Each pupil is encouraged to inflate his/her balloon a little and then try to push it under the water. The teacher asks the pupils what they think will happen if they inflate the balloon further. Then the pupils are asked to do this and repeat the same process two to three times, but each time inflate the balloon further. The teacher asks the pupils about any relationship between the increase of the balloon's volume and the magnitude of the buoyant force. See **Worksheet 3 in Lesson 2** for this experiment.

Tip - As the pupil pushes the inflated balloon in the water, he/she can feel the upthrust from the buoyant force. The more the pupils inflate the balloon, the harder they need to push in order to immerse it. This reveals the fact that the upward force which the water exerts becomes greater. We can thus conclude that the buoyant force depends directly on the amount of an objects' immersed volume. ***So, the greater the objects' immersed volume, the greater the buoyant force becomes.***

Tip - Both experiments should be repeated after reducing the amount of water in the tank. The purpose of this modification is to demonstrate that buoyancy does not depend on the amount of water in which we immerse an object. If it is not possible to repeat the experiments, the teacher needs to ensure that the pupils do not believe that the greater the amount of water in which we immerse an object, the greater the exerted buoyant force. This is not the case. ***Buoyancy does not depend on the amount of water in which we immerse an object.***

Tip - In the first two experiments the pupils recognise the existence of an up-thrust force that the water exerts on every object placed into it. They also recognise how this force depends on the immersed volume of the object. With the following experiments, the pupils investigate to clarify their concepts of weight and volume and how these physical quantities affect floating and sinking.

2.4 Changing the Weight –Experimenting in groups - 15 minutes

The teacher asks the pupils to predict what will happen if they place a small plastic box full of marbles in the water tank. The pupils then do this and note down their observation. The teacher can also ask pupils to predict what will happen if they repeat the same process 2 – 3 times, but each time reduce the number of marbles in the plastic box. Every time the pupils perform this experiment and they write down their observations. The teacher asks the pupil teams which variable was changed, which remained constant and what was the effect on the ability of the object to sink or float. See **Worksheet 4 Lesson 2** for this experiment.

Tip - When the plastic box is full of marbles it will sink because the box's weight is greater than the buoyant force, which is exerted by the water on the box. As the pupils remove marbles from the box, they reduce the box's weight, while the volume of the box remains constant. There will be a point (when enough marbles are removed) when the buoyant force will equal the box's weight and that is when the box floats. However, some pupils may think that the buoyant force will need to be greater than the box's weight in order for the box to float. In this situation, the teacher should ask: If buoyancy (upward force) is greater than the object's weight (downward force) then why isn't the object ejected out of the water?

2.5 Changing the volume (size) – experimenting in groups - 15 minutes

Pupil teams place the marbles they used in Experiment 3 inside a deflated balloon and seal the nozzle with a paper clip. The pupils are asked to predict the outcome of each experiment. Then they place the balloon into the water tank. After that, the pupil teams inflate the balloon, seal its nozzle with a paper clip and put it into the water tank. Finally, the teacher asks the pupil teams which variable was changed, which remained constant and what was the effect on the ability of the object to sink or float. See **Worksheet 5 in Lesson 2** for this experiment.

Tip - Initially, the balloon stuffed with marbles sinks to the bottom of the water tank as the balloon's weight is greater than the buoyant force exerted by water. When the balloon, stuffed with marbles, is fully inflated, it floats. This happens because the immersed volume of the balloon results in a buoyant force equal to the balloon's (plus marbles) weight.

<u>Variation of activity 2.5</u>[1]

Pupils put a balloon filled in with marbles and added water in the water tank. After that, they are asked to place inside the same balloon some baking powder carefully folded inside a paper napkin and then to seal the nozzle of the balloon with a paper clip and put the balloon into the water again. Pupils wait and see what happens (baking powder + water produces gas which will inflate the balloon). After that the pupil teams are asked to explain the outcome of their experiment.

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[1] If you chose the variation you should slightly modify the 3rd step of the 4th experiment in the Worksheet 5 of Lesson 2.

Tip - The stuffed balloon will initially sink because its weight is greater than the buoyant force exerted on the balloon by the water. As the napkin gets wet, a chemical interaction takes place between water and baking powder. This interaction produces gas which inflates the balloon. As a consequence, the balloon begins to inflate (increasing its volume) and the buoyant force gradually getting bigger and bigger. When the buoyant force becomes greater than the balloon's weight, the balloon begins to move towards the water's surface. When the balloon reaches the surface, the amount of the balloon's immersed volume becomes smaller and so, therefore, does the buoyant force (see Experiment 4). At some point, the buoyant force becomes equal to balloon's weight and that is when the balloon floats (weight = buoyancy and hence floating occurs).

2.6 Explain your observation – experimenting - 10 minutes

The teacher asks pupils take a box half full with marbles, and a single marble and then to place the box and the single marble in the water tank simultaneously and observe what happens. Afterwards, the teacher asks the pupils to give an explanation for their observation see **Worksheet 6, Lesson 2** for this experiment. In order to explain the results of this experiment, pupils need to apply knowledge obtained from the previous experiments. In that way, the teacher may observe the impact of the learning on the pupils.

Tip - The single marble will sink, while the box will float. The half full box of marbles, may have greater weight than the single marble but the box has also greater volume than the single marble. This means that the plastic box can displace (take the place of) a greater amount of water than the single marble. As a consequence, the buoyant force exerted on the box is greater than the buoyant force exerted on the single marble. So in the case of the plastic box, the buoyant force equals the weight of the box (with marbles) and the box floats. This does not happen in the case of the single marble. If we want to cut a long story short, we can say that the box may be heavier than the single marble, but the box has a smaller weight for its size compared to that of the single marble.

Tips considering activities 2.2-2.6

- *The teacher needs about 45 minutes to prepare this section of the unit.*
- *Pupils are grouped in teams of 4 – 5 members, depending on the total number of pupils in the class.*
- *The teacher encourages the members of each group to interact with each other in order to exchange opinions on every step of the activities and cooperate with each other.*
- *If the estimated time for the whole experimental process is insufficient the last experiment (activity 2.6) can be demonstrated by the teacher, but note that the explanation of the experiment's outcome should be given by the pupils.*

2.7 Conclusion – plenary - 30 minutes

After the end of activities 2.2 – 2.6, the teacher asks the pupil teams to look at Table 1.1 from Lesson One, Activity "Floating or Sinking" and reflect on what they predicted about which object was going to float and which was not. The teacher asks them to choose 2-3 objects from this list (preferably objects for which they predicted wrongly) and try to explain why these objects behave in way they did use **worksheet 7, lesson 2**. Pupils, by the end of Lesson Two are expected to learn that an up-thrust force is exerted on every object immersed in water, namely the buoyant force, which increases as the immersed volume of the object increases. If the weight is greater than the buoyant force, the object sinks. At the point where the immersed volume of the object leads to a buoyant force equal to its weight, the object floats. Pupils are also expected to adopt the scientific process of making predictions, testing them through experiments, interpreting the observations, and reaching to conclusions. Finally the teacher asks the pupils what they need to take into account regarding the properties (in terms of volume and weight) of the materials which they need to choose in order to design the floating platform in Lesson Three. The teacher must be sure that the pupils recognise that the condition **buoyancy = weight** is easily met when the platform is as light as it can get and at the same time, it's volume (size) is as big as possible. At the end of this lesson (as in lesson One), the pupils can be asked to identify the steps of EDP in their work and for this, the teacher can ask them something like the following:

"Think of the work you have carried out in lesson 2. What you think? Does this work connect with any step of the EDP? If yes, which ones?"

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Lesson 3 – Let's build!
Design and build your own floating platform.

Duration: 175] minutes

Objectives: in this lesson the pupils will learn

- That in order to give a solution to an engineering problem, engineers use a series of steps called the Engineering Design Process (EDP).
- That in order to design and implement a functional solution to an engineering problem, they rely on the science (physical principles) which underpins the problem.
- That the platform can be built in various ways and the construction will be successful as long as it meets certain criteria. Thus, there is not only one right solution to the problem.

Resources for 30 pupils (6 groups of five pupils each)

- 12 plastic milk bottles (2 bottles per group)
- 240 zip ties also known as tie wraps (40 per group)
- 36 pvc pipes (22mm in diameter/40 cm long, 6 pipes per group)
- 6 thin corex (also known as coroplast) or mount-board cut into 4 pieces (40 cm x10 cm each).
- 6 duct tapes
- 6 thin pieces of rope or fishing line
- 180 Styrofoam cups (30 cups per group)
- 6 pieces (40 cm x 40 cm) of plastic net
- Pencils and permanent markers
- 6 Scissors
- 6 Rulers
- 6 sets of Activity Worksheets

Preparation

- collect and organise the materials
- fill the tank with water
- photocopy the lesson 3 worksheets
- if necessary read the **"Instructions Sheet"** (skills for building the raft) in Additional Appendices
- Fill the water tank

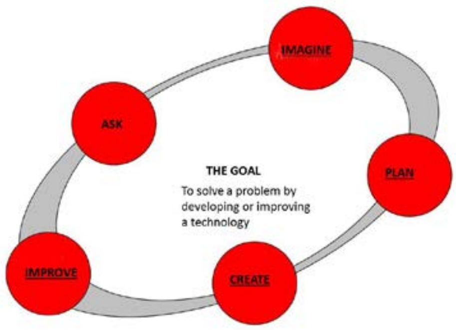
Working method

- Working in groups
- Plenary

Key ideas in this lesson

- Work like an engineer
- Design and Build

Context and background *In this lesson pupils are thoroughly introduced to the Engineering Design Process (EDP) and apply the steps of EDP in order to face up to their engineering challenge. These steps are: 1)* ***Ask*** *appropriate questions concerning the problem, and the criteria that your solution must meet, 2)* ***Imagine*** *possible solutions, 3)* ***Plan*** *carefully how to implement one of your ideas or combine a number of your ideas into one design, 4)* ***Create*** *your design and test to see if it meets your criteria, 5)* ***Improve*** *your design and make it even better; test it again. As part of the EDP process, the pupils need to recall the scientific knowledge they gained in Lesson Two.*



3.1 Introductory activity – working in groups - discussion - 15 minutes

Pupils remain in groups as in Lessons One and Two. The teacher reminds the pupils about the conclusions from Lesson Two: The condition **buoyancy = weight** is met when the platform has a **small weight for its size/volume or large volume for its weight.** If the weight is greater than the buoyant force, the object sinks. When the immersed volume of the object gives a buoyant force equal to its weight the object floats. The teacher points out the context of the engineering challenge the pupil teams have to face. Furthermore, the teacher seizes the opportunity to begin a thorough discussion about EDP and to describe each step of the process in more detail (the main characteristics of each step can be found in the following bullets). At this point, the teacher provides the pupil teams with the "**Engineering Design Process Sheet"** found in the Appendix. The EDP comprises five steps ("Ask", "Imagine", "Plan", "Create", and "Improve").

- **Ask**
  What is the problem?
  What kind of materials do we have at our disposal?
  What do we need to know concerning the science that underpins the problem?
  What are the constraints of the problem?
  Which are the criteria that must be met so that the solution will be functional?
- **Imagine**
  What could be some solutions?
  Brainstorm ideas
  Choose the solution that appears to be the best
- **Plan**
  Draw a diagram of the chosen solution
  Make a list of materials you will need
- **Create**
  Follow your plan and develop your solution.
  Test your solution to check if it meets the criteria.
- **Improve**
  Make your design even better.
  Test it again.

3.2 Ask-Activity 2 – discussion - working in groups –10 minutes

The goal of activities 2 – 6 is the construction of the floating platform by implementing the EDP. Following the first step of EDP ("Ask"), the teacher asks the pupil teams to think about what they have already learned and then to propose questions about what else they need to find out in order to start imagining and planning possible solutions. At this point the teacher provides the groups with **Worksheet 1 in Lesson 3 ("Ask").** This leads the pupil teams to think about the constraints to solving the problem *e.g. what materials are available to use?*. The whole class, along with the teacher, need to decide on the criteria *(e.g. How do we know whether we succeeded in our task or not?)* that must be met and are common to all. Some criteria can be the following:

- **The platform must float.**

- **The platform must withstand as much load as possible given the size constraints (magazines, books, refreshments, etc.).**
- **When loaded, the platform clearance above the water must not be less than 10 cm.**
- **The platform must be stable, which means that it will not capsize as consequence of small waves in the sea.**
- **Security measures are foreseen so that the platform's cargo will not roll fall into the water.**

At this point, the teacher provides the available materials (see Resources) to the teams and informs them that it is not obligatory to use all the materials as there is not only one solution to the problem. The teacher should encourage the teams to use and combine any materials they think appropriate in order to develop a functional solution that meets the criteria previously established.

3.3 Imagine-Activity 3 – working in groups - 10 minutes

The teacher proceeds to the second step of the EDP ("Imagine"). The teacher encourages the pupil teams to imagine possible solutions to their problem using **Worksheet 1, Lesson 3 ("Imagine").** The pupils discuss among themselves their proposed ideas and even draw sketches about how the platform will look like. Furthermore, the pupils of each team need to cooperate, and exchange ideas on how to use the available materials.

3.4 Plan-Activity 4 – working in groups - 10 minutes

Finally, the pupil teams move to the third step of EDP ("Plan"). Now each team, based on the ideas of its members as proposed in the "Imagine" step, decides on the most suitable solution for the challenge. In order to proceed to the implementation of the chosen solution, the pupils first explore the materials, discuss all possible details concerning implementation of their solution and finally draw a clear sketch of the platform. In this sketch, the materials and other details need to be shown and labelled (at this point the teacher asks the pupil teams to use the Worksheet 1, Lesson 3 ("Plan")). During this step, the pupil teams need to always bear in mind the constraints and the criteria that must be met. The teacher makes it clear that the sketch – diagram serves as a blueprint, which will guide them in their effort to construct the platform. However, it is important to point out that pupil teams should not spend too much time in making diagrams, as they will then struggle to complete a real, 3D object in time. The teacher should not let this happen as pupils are usually eager to start the practical work and it is critical to maintain their interest.

3.5 Create-Activity 5 – working in groups - 75 minutes

The teacher, after making a short review of the first three steps of EDP, leads the pupil teams to the implementation of the fourth step - "Create". During this step, each group needs to follow the diagram formed in the previous step and proceed to the construction of the platform. It is essential that the groups become involved as much as possible with every aspect of the platform construction. In order to proceed with the construction of the platform, some practical skills such as Fastening and Cutting are needed. It is important that the teacher spends time in teaching these skills to the pupils. A brief guide concerning cutting and fastening is given in the Appendix **Instruction Sheet.** At this point teams use Worksheet **1, Lesson 3. ("Create").** When constructed, each group places the platform in the water tank and test its compatibility with the set criteria.

3.6 Improve- Activity 6 – working in groups - 45 minutes

In the last step of the EDP "Improve", pupils improve their designs, based on whether they were successful in fulfilling the criteria using **Worksheet 1, Lesson 3 "Improve".** Even if the criteria are met, the designs can still be further improved as one group might wish to adopt ideas from other groups. When each team completes their improvements on their design, they test it again.

Tip - The teacher's guidance is necessary throughout the whole construction process. In case the teacher feels that there are practical procedures that could be unsafe for the pupils, the teacher should undertake these.

Tip - The items to use as a load on the platform are not included in the list of materials. All pupil teams need to agree beforehand on the objects they will use for this purpose and bring them from home.

A platform construction is regarded as successful if it meets all the defined criteria. The winning design is the one that best holds the objects loaded on the platform. This corresponds to a score that is calculated by assigning points to each object used as a load. Pupils need to agree beforehand on the number of points assigned to each object, for instance a magazine equals 1 point.

3.7 Conclusion – plenary - 10 minutes

By the end of the lesson, the pupils are expected to have learned that engineers use a series of steps in order to solve a problem. Pupils are asked to reflect on the main activity (activities 2 – 6) and identify in their performance, the steps of EDP. The teacher points out that engineers rely on the science underlying a particular problem they face in order to reach suitable solutions. The teacher should ask pupils to think whether it would be easier, or more difficult, to design their floating platform without knowing the answers to the investigative questions they were set in Lesson Two. The teacher should also points out to the pupils that although their designs differ from one another they were still able to meet the required criteria, so there is not only one right solution to the problem. Finally, the teacher could ask pupils to suggest other problems in which their floating platform can be a solution or propose other ways to use it.

Lesson 4 – How did we do?
Is the challenge met?

Duration: 120 minutes

Objectives, in this lesson the pupils will learn:

- To review and evaluate their work.
- To present their work in front of an audience.
- To make wider links between science and engineering

Resources (for 30 pupils- six groups of 5 pupils each)

- Set of coloured markers for each group.
- Paper block suitable for a flipchart for each group.
- A flipchart.
- Worksheet 1 Lesson 4

Preparation

- Collect the materials
- Print the lesson 4 worksheets
- Print pictures for the conclusion activity (see appendix)

Working method

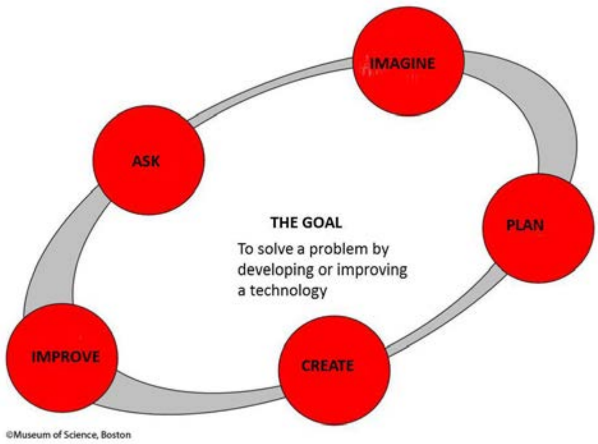
- Working in groups
- Plenary

Key ideas in this lesson

- Explain a project to an audience
- Science and Engineering – A bidirectional relation.

Context and background

This lesson intends to help pupils realise how they used the EDP in solving a certain engineering problem. They come to realise that they activate parts of this process in solving other other everyday challenges. At the end of Lesson 4, pupils need to possess skills regarding the presentation of their work to an audience. Also by the end of this lesson, pupils need to grasp fundamental science concepts related to the phenomenon under investigation and expand their knowledge to other related phenomena. For example, they need to understand how submarines sink and float, or how ships float.



4.1 Introductory activity – review EDP Steps – discussion-working in groups - 30 minutes

The teacher gives a short overview of lessons 1-3 and points out the conclusions they have reached at previous stages. The teacher initiates a discussion prompting the pupils to reflect on every aspect of the process they followed, from the beginning to the end of the challenge, and then summarise their work under the headings of the EDP. The pupil teams are asked to fill in Table 4.1 **worksheet 1, lesson 4**. The pupils may also discuss how the EDP can be applied to other engineering problems. The teacher writes notes on the board, summarising the pupils' answers.

4.2 Present your work – working in groups –60minutes

Based on the preceding introductory work, each group of pupils is asked to make a presentation of the outcome achieved in facing the particular engineering challenge, in the form of a small poster to hang on the wall of the class. When the posters are finished, each group gives a short presentation to the rest of the class using the poster as an illustration. The poster needs to illustrate the following information: a) the nature of the engineering challenge they needed to solve and the underlying science, b) the steps they followed in order to solve the problem, c) an evaluation of their work – what could be done in a different manner, the problems they faced, and d) photos from the various stages of the development of the platform.

4.3 Conclusion – plenary - 15 minutes

At the end of the lesson, the teacher facilitates an expansion of the learning through establishing wider links between science (floating/sinking principles of physics) and other applications in the field of Ocean Engineering. Photographs of ships and submarines (see additional appendices) can be presented to the pupils and a discussion can take place regarding why ships and submarines can sink or float.

- Ships despite their huge weight are able to float. Can you explain why?
  Ships may indeed have a huge weight but their immersed volume is large enough to cause a buoyant force that equals the ship's weight.
- Can you explain how a submarine is able to emerge and submerge?
  By manipulating its weight. When the submarine fills its tanks with water, its weight becomes greater than the applied buoyant force and so it submerges. This continues to happen, up to the point when its immersed volume leads to a buoyant force which equals its new weight and so it floats below the water's surface (submerged).
  If the captain wants to change the depth of the submarine all he/she has to do is to use the fins and the flaps of the submarine in the same way that a pilot does with an aeroplane in order to change its flying height.
  When the submarine empties its water tanks then the applied buoyancy becomes greater than its current weight and the submarine emerges. This happens up to the point when the new immersed volume of the submarine causes a buoyancy force equal to its new weight and the submarine floats on the surface of the sea.

Furthermore, the teacher should point out that while engineering relies on scientific knowledge, engineering also feeds science with new questions.

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Appendices

Story to set the context

"Design your own floating platform"

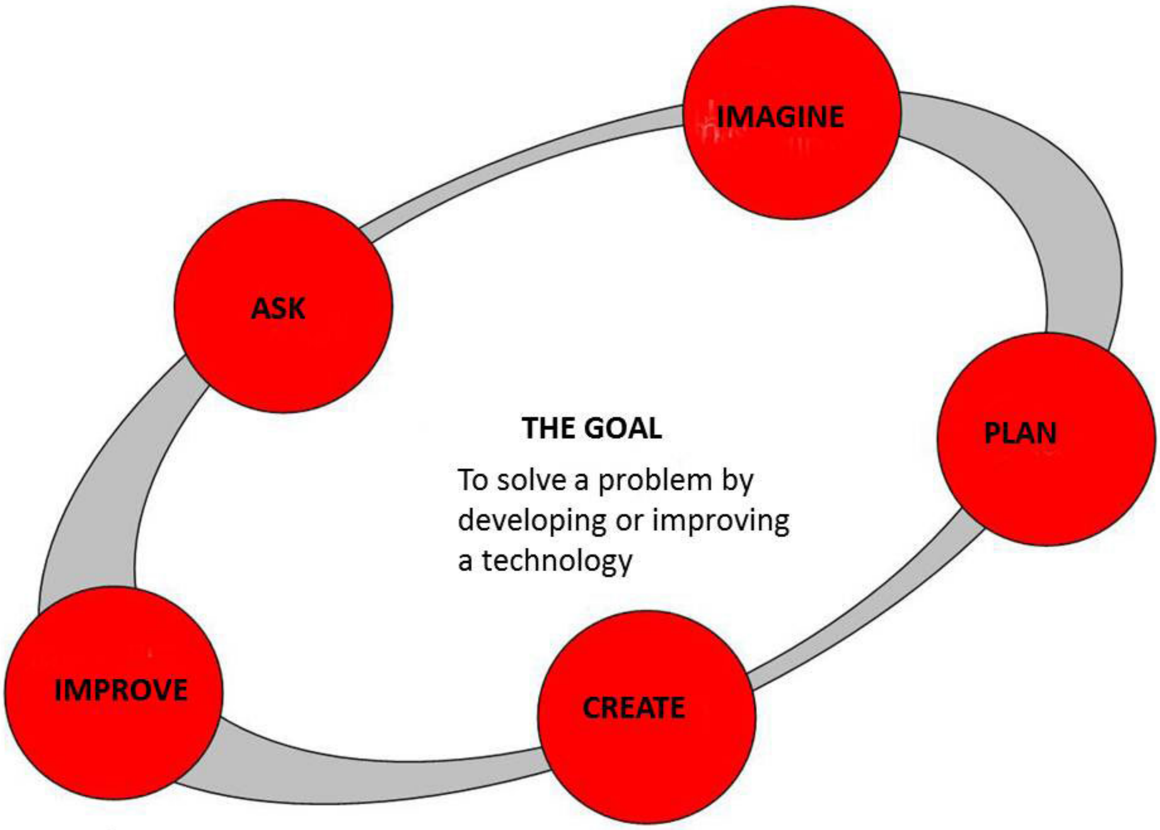
Hronis and Helen come from a Greek island called Ikaria. Every day they visit a small deserted island located within swimming distance off the beach where they live. In fact Hronis who is 1,60m does not really need to swim to approach the island since the water is not really that deep. However, they do have a problem! They cannot take anything with them on the island such as their books, mp3 players, video games and their refreshments since they don't have a boat. They always need to leave their things on the nearest beach, swim or walk to the island and come back again quickly if they do not want to lose them.

One day they found a solution to their problem. The two children visited their uncle who works as an Ocean Engineer on a floating platform in the region of Crete. He told them about his line of work and explained to them in detail the use of floating platforms in various tasks in the ocean. However, the fact that intrigued the children was that scientists and engineers were actually living on the platform.

That's when an idea was formed! Helen, having seen the floating platform where her uncle worked, suggested to Hronis that they should build one for themselves in order to solve their problem regarding the transfer of their things to the island once and for all. Hronis was thrilled by the idea and got even more excited when he heard that this was a plausible scenario. It took less than an hour for their uncle to make a detailed sketch of the platform and a brief list of materials for its construction, which in engineering lingo is called BOM or bill of materials.

Did the children manage to create their floating platform? Are you and your team able to create something like that? Try to construct a model floating platform for your own use. Your teacher can always help you!

Engineering design cycle



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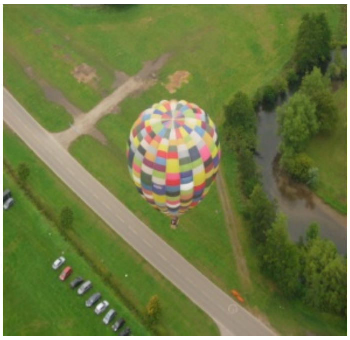
Worksheets and answer sheets

Worksheet 1 Lesson 0 – Engineering?








Worksheet 1 Lesson 0 - Engineering? – Teacher notes

The pictures on the worksheet are intended to promote pupils' discussion about what engineering is, what engineers do and who could be involved in different types of engineering.

The pictures of the spider and snail present some interesting challenges. The pupils could for example, decide that the spider is 'engineering' a web and this could be related to other animal 'engineering' examples (such as a beaver building a dam). An interesting point to make is that it is more common to think of engineering in terms of the made world. We can however, learn from studying nature and the environment. For example, the material that spiders use for making a web has been copied to make a very strong material (Kevlar) that has many useful properties. Similarly, the snail has developed a useful strategy for travelling over rough surfaces to protect its soft body from being damaged. An interesting question is whether this would be useful to solve a problem in the human world (a good example is Velcro which was developed from the burrs of burdock plant).

The toys could be considered engineering since they demonstrate the application of cams but it is interesting to ask what materials they could be made from and who actually makes them. This is likely to lead to some gender issues (many of the class may think that toys are made for children by toy designers who are male).

A similar issue might arise when pupils discuss the knitted garment and the prepared meal - pupils may think that these are only made by women, and that they are not the product of engineering.

Some of the other pictures of sculptures and works of art might be perceived as not engineering and without any real practical purpose. This will raise a question about the links between engineering and art and whether or not a made object needs to have a practical purpose for it to count as being engineering.

The pictures are meant to stimulate engagement and dialogue about engineering. This could lead to a discussion about what is involved in engineering, in which you might choose to introduce the Engineering Design Cycle.

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Worksheet 1 Lesson 1- Setting the problem

Team Name:
Date:

To work!

1. Please make a note of the kinds of materials your group thinks are suitable for the construction of a floating platform.

   ……
   ……
   ……

2. Which are the materials that the other groups suggested?

   ……
   ……
   ……

3. Are there any similarities among the materials in terms of properties (such as weight, size, material etc.) proposed by the pupil teams? If so, what are they?

   ……
   ……
   ……

4. What about the differences? Are there any? If so what are they?

   ……
   ……
   ……

Worksheet 2 Lesson 1- Floating or Sinking?

Team Name:
Date:

What do we need?

- ☐ Soft drink
- ☐ Paper clip
- ☐ Plastic box half full of paper clips
- ☐ Candle in shape of a ball or a big cylinder
- ☐ Cork stopper
- ☐ Plasticine
- ☐ Milk can
- ☐ Small rock
- ☐ Tennis Ball
- ☐ Balloon
- ☐ piece of Styrofoam
- ☐ piece of wood
- ☐ Bottle of water
- ☐ Shampoo
- ☐ Orange (and the orange without the peel)
- ☐ thin bar of soap
- ☐ Bucket filled with water

To work!

Fill in the Table

Table 1.1.

Item	*Prediction (Float/Sink)*	*Observation*

Worksheet 3 Lesson 1- Conclusion!

Team Name:
Date:

To work!
Fill in the Table

Table 1.2	
Floating Items	***Sinking Items***

Worksheet 1 Lesson 2 – Starting an investigation

Team Name:
Date:

After Lesson 1, you understand that weight is not the only factor that affects sinking and floating. What other factor/s affect the behaviour of an object in water? How are these factors related? What else do you need to know?

To work!

1. Discuss with the other members of your team and propose questions which if you knew the answers, you will be able to imagine and design solutions to your engineering problem.

   ....
   ....

2. What are the investigative questions finally decided by the class?

   ....
   ....

Table 2.1		
Investigative Questions ⇒	....	
	What will I change? (independent variable)	What will I observe or measure? (dependent variable)

Worksheet 2 Lesson 2 – Exploring the force of buoyancy

Team Name:
Date:

What do you need?

- Fishing Weights
- Dynamometer
- Bucket with water

To work!

1. Predict what will happen if you place a fishing weight in the water tank

   ....

2. Place a fishing weight in the water tank.

   What do you observe? Which force/forces act on the object?

   ....
   ....

3. Take the dynamometer and use it to weigh each fishing weight. Write down the reading on your dynamometer in Table 2.2.

   Why is the dynamometer stretched?

   ....

   What will the reading on the dynamometer be, if you weigh objects under the water? Will the readings be the same, smaller or greater? Write down your prediction.

   ....
   ....

4. Now, hang a fishing weight (one at a time) on the dynamometer and slowly immerse the object in the water until it is fully covered with water. Write down the reading on the dynamometer.

   What do you observe? Compare the result of this observation with the result of the previous one.

   ....
   ....

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Table 2.2			
Fishing Weight	Weight outside the water	Weight in the water	Observational differences
1			
2			
3			
4			

5. Are there any differences between the two results, and if so can you explain why?
   ………
   ………

6. Let us assume that we repeat the same process with less water in the tank. What will be the reading on the dynamometer, if you weigh the objects in the water? Will the reading be the same, smaller or greater? Write down your prediction
   ………
   ………

If you are not sure about it you only have to check it out. By experimenting you will get your answer.

Worksheet 3 Lesson 2 – Buoyancy - Volume (Size). An Inseparable Relation

Team Name:
Date:

What do you need?

- Balloon
- Bucket with water

To work!

1. Take a balloon and inflate it a little. Predict what will happen if you try to push the balloon into the water in the tank. Will it sink or not?
   ……

2. Try to push the balloon into the water in the tank.
   Is it easy for you to do this? What do you observe?
   ……

3. If you inflate the balloon more, what do you expect to happen if you try to push the balloon into the water in the tank again? Will it be easier or more difficult than the previous try?
   ……

4. Inflate the balloon more and push it into the water in the tank (repeat this procedure 2 – 3 times, but each time inflate the balloon more than the previous time).

   What do you observe?
   ……

5. If you repeat the same process, but this time with much less water in the tank, do you believe that it would be easier to push the balloon into the water? Check it out!
   ……

6. When was it more difficult to push the balloon into the water? Was it when the balloon was more, or less inflated? So, what factor, do you believe, affects the up-thrust force that acts on the balloon?
   ……
   ……

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Worksheet 4 Lesson 2 – Changing the Weight

Team Name:
Date:

What do you need?

- Plastic Toothpick Box
- Marbles
- Bucket with water

To work!

1. What do you believe will happen if you place a plastic box full of marbles in the water tank? Why?

   ....

2. Place the plastic box (which is full of marbles) in the water tank.
   What happens? Why?

   ....

3. If you start removing marbles from the plastic box, what do you think would happen when you place the box in the water tank? Why?

   ....

4. Progressively remove 1 marble at a time from the box. Each time place the box in the water tank. Note down your observations. As you progressively remove marbles do you observe something different?

   ....

5. By removing marbles, what did you change concerning the properties of the box?

   ....

Worksheet 5 Lesson 2 – Changing the Volume (Size)

Team Name:
Date:

What do you need?

- Balloons
- Marbles
- Paperclips
- Bucket with water

To work!

1. Stuff the balloon, with the same number of marbles as in Worksheet 4.2. Seal the nozzle of the balloon with a paper clip. Predict what will happen if you place the balloon in the water tank.

   ………

2. Place the balloon in the water tank, does it sink or float? Why?

   ………

3. Inflate the balloon with some air and seal the nozzle with a paperclip. Predict what will happen if you now place the balloon in the water tank. Place the balloon in the water. Does the balloon sink or float? Why?

   ………

4. In which of the two cases is the buoyancy force exerted on the balloon greater, when the balloon was inflated or when it was not?
   Through inflation, what did you change concerning the properties of the balloon?

   ………
   ………

5. Consider now the conclusions obtained from experiments 3 and 4 and answer the questions below: What properties, in terms of weight and volume must an object possess, in order to float. Choose the right answer/s.
   i. Small weight for its volume
   ii. Huge weight for its volume
   iii. Small volume for its weight
   iv. Large volume for its weight

Worksheet 6 Lesson 2 – Explain your observation

Team Name:
Date:

What do you need?

- Plastic box
- Marbles
- Bucket with water

To work!

1. Take a half full of marbles in the box and single marble. Place them simultaneously in the water. What happens? Why?

   ……

2. So what do you think that someone needs to bear in mind if he/she wants to build a platform that carries the most possible weight and still floats?

   ……

Worksheet 7 Lesson 2 – Conclusion

Team Name:
Date:

1. Choose an object (from the list given in Lesson One) for which your prediction about floating/sinking was wrong. Can you now explain why the object behaved in a different way than the one you imagined in the first place?
……
……

2. Can you give a brief description about the procedure you followed in order to obtain the needed knowledge for beginning to imagine about possible solutions to the engineering challenge you faced?
……
……

3. What should you take into account regarding the properties (in terms of volume and weight) of the materials to choose in order to design the floating platform in Lesson 3?
……
……

Answer sheet Worksheet 1 Lesson 2 - Starting an investigation

Team Name:
Date:

By the end of Lesson One, you understand that weight is not the only factor that affects sinking – floating. Are there any other factor/s affecting the behaviour of an object in water? How are these factors related?

What do you need?

- Ruler (not wooden)

To work!

1. Discuss with the other members of your team and propose questions (concerning the physics of the problem) which if you knew the answers, you will then be able to imagine and design solutions to your engineering problem.
   ………
   ………

2. What are the investigative questions that the classroom finally decided?

   - **What prevents an object that floats from moving towards the bottom of the sea?**
   - **Does water exert a force on any objects we immerse into it? If so, on what does this force depend?**
   - **What is the relationship between the weight of an object and its volume (size) so that the object can float?**

Table 2.1		
Investigative Question ⇒	**E.g. What is the relationship between the weight of an object and its volume (size) so that the object can float?**	
	What will I change? (independent variable)	What will I observe or measure? (dependent variable)
Investigation 1	**Weight**	**Floating or sinking**
Investigation 2	**Volume (size)**	**Floating or sinking**

Answer sheet Worksheet 2 Lesson 2 – Reveal the force of buoyancy

Team Name:
Date:

What do you need?

- Fishing Weights
- Dynamometer
- Bucket with water

To work!

1. Predict what will happen if you place a fishing weight in the water tank
   It sinks.

2. Place a fishing weight in the water tank.

   What do you observe? Which force/forces act on the object?
   It sinks.
   The forces that act on the object are buoyancy and weight

Tip - Pupils will, for sure, refer to weight, but probably not buoyancy – they may refer to a force acting from water to the object but with no further details.

3. Take the dynamometer and use it to weigh each fishing weight. Write down the readings on your dynamometer in Table 2.2.

   Why is the dynamometer stretched?
   Due to the force of weight

   What will be the readings on the dynamometer, if you weigh the objects under the water? Will the indications be the same, smaller or greater? Write down your prediction.
   ………

4. Now, hang a fishing weight (one at a time) on the dynamometer and slowly immerse the object in the water until it is fully covered with water. Write down the reading on the dynamometer.

   What do you observe? Compare the result of this observation with the result of the previous one.
   The reading on the dynamometer is smaller each time whne the object is in the water than outside of it.

Table 2.2

Fishing Weight	Weight outside the water	Weight inside the water	Observational differences
1			
2			
3			
4			

5. Are there any differences between the two results, and if so can you explain why?
There are differences between the two results. This difference is due to the up thrust force of buoyancy exerted on the object while immersed in the water. In that way the spring is less stretched giving the impression that the object is less heavy in the water.

6. Let us assume that we repeat the same process with less water in the tank. What will be the reading on the dynamometer if you weigh the objects in the water? Will the indications be the same, smaller or greater? Write down your prediction.
....
....

If you are not sure about it you only have to check it out. By experimenting you will get your answer.

Tip – The reading on the dynamometer will be the same as it does not depend on the amount of water in the tank.

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Answer Sheet Worksheet 3 Lesson 2 – Buoyancy - Volume (Size) An Inseparable Relation

Team Name:
Date:

What do you need?

- Balloon
- Bucket with water

To work!

1. Take a balloon and inflate it a little. Predict what will happen if you try to push the balloon into the water in the tank. Will it sink or not?
   ....

2. Try to push the balloon into the water in the tank.

   Is it easy for you to do this? What do you observe?
   It is quite difficult to push the balloon into the water.

3. If you inflate the balloon more what do you expect to happen if you try to push it into the water in the tank again? Will it be easier or more difficult than for the previous try?

   ....

4. Inflate the balloon more and push it into the water in the tank (repeat this procedure 2 – 3 times, but each time inflate the balloon more than the previous time).

   What do you observe?
   The more we inflate the balloon, the harder it gets to push it into the water.

5. If you repeat the same process but this time with much less water in the tank, do you believe that it would be easier to push the balloon? Check it out!
   The difficulty will be the same because the amount of water does not play any role in the magnitude of buoyancy.

6. When was it more difficult to push the balloon into the water? Was it when the balloon was more, or less inflated? So, what factor do you believe affects the up-thrust force that acts on the balloon?

   The more we inflated the balloon the harder it got to push it into the water. The buoyant force depends directly on the amount of an objects' immersed volume. The greater the immersed volume, the larger the buoyant force.

Answer Sheet Worksheet 4 Lesson 2 – Changing the Weight

Team Name:
Date:

What do you need?

- Plastic Toothpick Box
- Marbles
- Bucket with water

To work!

1. What do you believe that will happen if you place a plastic box full of marbles in the water tank? Why?
   ……
2. Place the plastic box (which is full of marbles) in the water tank.
   What happens? Why?
   It sinks because the box's weight is greater than the buoyant force, which is exerted by water on the box.
3. If you start removing marbles from the plastic box, what do you think would happen when you place the box in the water tank? Why?
   ……
4. Progressively remove 1 marble from the box. Each time place the box in the water tank. Note down your observations. As you progressively remove marbles do you observe something different?
   Yes, the plastic box floats when the necessary amount of marbles is removed.
5. By removing marbles what did you change concerning the properties of the box?
   We changed the weight of the box.

Answer Sheet Worksheet 5 Lesson 2 – Changing the Volume (Size)

Team Name:
Date:

What do you need?

- Balloons
- Marbles
- Paperclips
- Bucket with water

To work!

1. Stuff the balloon, with the same number of marbles as in Worksheet 4 Lesson 2. Seal the nozzle of the balloon with a paper clip. Predict what will happen if you place the balloon in the water tank.
   ……

2. Place the balloon in the water tank, does it sink or float? Why?
   It sinks because the weight is greater than the buoyancy force.

3. Inflate the balloon with some air and seal the nozzle with a paperclip. Predict what will happen if you place the balloon in the water tank. Now place the balloon in the water. Does the balloon sink or float? Why?
   It floats because the buoyancy is equal to the balloon's weight.

4. In which of the two cases is the buoyancy force exerted on the balloon greater, when the balloon is inflated or when it is not?
   Through inflation what did you change concerning the properties of the balloon?
   The buoyancy force was greater when the balloon was inflated. Through inflation we changed the volume (size) of the balloon.

5. Consider now the conclusions obtained from experiments 3 and 4 and answer the questions below: What properties, in terms of weight and volume must an object combine, in order to float. Choose the right answer/s.
   i. Small weight for its volume
   ii. Huge weight for its volume
   iii. Small volume for its weight
   iv. Large volume for its weight

Answer sheet Worksheet 6 Lesson 2 – Explain your observation

Team Name:
Date:

What do you need?

- Plastic box
- Marbles
- Bucket with water

To work!

1. Take a box half full of marbles and single marble. Place them simultaneously in the water. What happens? Why?
   The single marble sinks while the box floats. In the case of the single marble, its weight is greater than its buoyancy. In the other case, the box, due to its bigger volume, is subjected to buoyancy force that equals its weight, so it floats.
2. So what do you think someone should bear in mind if he/she wants to build a platform that carries the most possible weight and still floats?
   That his/her construction should be as light as possible and at the same time it's volume (size) should be as large as possible.

Answer sheet Worksheet 7 Lesson 2 – Conclusion Weight – Size Relation

1. Choose an object (from the list of Lesson One) for which your prediction about floating/sinking was wrong. Can you now explain why the object behaved in a different way than the one you imagined in the first place?
   e.g. The candle. Although we thought that it should sink, the candle floated because it's immersed volume was big enough to lead to a buoyancy force that was equal to its weight.

2. Can you give a brief description about the procedure you followed in order to obtain the needed knowledge for beginning to imagine about possible solutions to the engineering challenge you have to face?
   1. **Find suitable investigative questions.**
   2. **Make predictions about possible answers.**
   3. **Conduct experiments in order to prove the preductions correct or incorrect.**
   4. **Reach conclusions from the results of the experiments.**

3. What should you take into account regarding the properties (in terms of volume and weight) of the materials which you need to choose in order to design the floating platform in Lesson 3?

   The materials should be as light as possible and at the same time their volume (size) should be as large as possible in order to lead to a buoyancy force that is equal to the weight.

Worksheet 1 Lesson 3- Engineer Design Process

Team Name:
Date:

To work!

Ask

1. Based on the conclusions we reached in Lesson 2, in what way should you design your platform so that it can float?

   ………

   ………

2. How are you going to test and evaluate your design? Set the criteria that your design should meet.

   ………

   ………

Imagine

3. Write down or sketch possible solutions to your problem that your team imagines.

Plan

4. List the materials that you have chosen to use.
5. In the box below, draw a detailed diagram of your group's platform design. Try to design all the material you are going to use and label them.

6. According to your plan and based on the sketch do you think your platform is going to meet the criteria? Why?

....
....

7. List the objects you will use to load your platform. Remember the teams must decide on the determination of points.

Object	**Points**
Total Score:	

Create

8. Fill in the Table below with the criteria that your design should meet. After testing your platform put a ✓ in the right box.

Criteria	**Success**	**Failure**

What is your score from loading the platform?	

Improve

9. Depending on the feedback you get from testing your design (please see Worksheet 2 Lesson 3 step "Create"). Fill in the questions below.

   Which parts of your floating platform design worked well?

   ....

   Which parts did not work well?

   ....

10. In what way will you try to improve your design? Write or draw these below.

Answer sheet Worksheet 1 Lesson 3- EDP

Team Name:
Date:

To work!

ASK

1. Based on the conclusions we reached in Lesson 2, in what way should you design your platform so that it can float?

   The platform should be as light as possible and at the same time its volume (size) should be as large as possible.

2. How are you going to test and evaluate your design? Set the criteria that your design should meet.
   For example:

   - **The platform must float**
   - **The platform must withstand as much load as possible given the size constraints (magazines, books, refreshments, etc.)**
   - **When loaded the platform clearance above the water must not be less than 10 cm.**
   - **The platform must be stable, which means that it will not capsize as a consequence of small waves in the sea.**

Worksheet 1 Lesson 4- Present Your Work

Name:
Date:

To work!

Review how you use the Engineer Design Process to solve the problem. In the table below fill in the boxes according to what you did during each step of the EDP in order to create your platform.

Table 4.1

ASK	IMAGINE	PLAN

CREATE	IMPROVE

Instructions Sheet

Fastenings

The making process is quite easy as it does not require specialized skills. The only "technique" needed is to understand the function of zip ties (tie raps).

Zip ties are really powerful fasteners and the only way to untie them is to cut them.

1. Pupils can use zip ties in order to tie the pipes together (Fig. 1). In that way they can assemble the frame of the floating platform (Fig. 2). It is better to use two zip ties in the shape of an **X** (Fig. 1) instead of one.]

Figure 1. Zip ties used to tie the PVC pipes together. In the figure you can see that the zip ties are crossed. In that way you can make sure that the bond will be strong enough.

Figure 2. In this picture we can see how we can keep on fastening pipes together in order to construct the frame of the platform.

Figure 3. In this picture we can see how 6 pipes can be tied together in order to construct the frame of a platform. Note that this design is only a suggestion. Pupils should be encouraged to imagine and design their own ideas. This picture serves only as an example of how we can fasten the pipes together.

2. There are of course some cases in which the zip ties are not long enough to tie something we want. In such cases the only thing we can do is to join two or more zip ties together (Fig. 4).

Figure 4. Two joined zip ties. In this way we can join together more than two zip ties in order to maximize the length.

3. The joined zip ties can be used to fasten the bottles on the frame of the platform (Fig. 5). Of course for the same reason, pupils can use fishing line, rope, or duct tape concerning each time the advantages and disadvantages of the material they use. For example, there is a possibility after intense use in the seawater, the duct tape will no longer stick to the bottles or the pipes.

Figure 5. An example of how the bottles can be fastened on the frame using joined zip ties.

4. For the floor of the platform pupils can use either the mountboard (or the corex), or the plastic net. There is a problem concerning how the pupils will fasten the mountboard (or the corex), on the frame. This is quite easy as the mountboard (or the corex), can be easily drilled using only a screw driver (Fig. 8). Through the holes of the mountboard (or the corex), the pupils can insert a zip tie (or joined zip ties) and then fasten the mountboard (or the corex), on the pipes of the frame (Fig. 9).The same process can be followed in the case of the net, in cases where the net's hole are too narrow for the zip tie to pass through.

5. Instead of using bottles as floats, one can construct floats using Styrofoam cups. The cups can be mounted using duct tape like in Fig. 6. A way of increasing the size of floats is by adding more cups (Fig. 7) and again tying them with duct tape, if necessary.

Figure 6. How to build floats made of Styrofoam cups.

Figure 7. How to increase the size of floats

Making Holes

Some holes in the mountboard or corex pieces can be made using a small screw driver, or other pointed tools (see figure 8).

Figure 8. How to drill a hole using a screw driver.

Figure 9. Fastened mountboard on the frame of the platform.

Cutting

For cutting the PVC pipes (in case you can't have them pre cut) you will need a pipe cutter (Fig. 10).

Figure 10. PVC Pipe Cutter

Figure 11. How to cut a PVC pipe

- Mark the pipe at the point where it needs to be cut. Use a permanent marker.
- Open the pipe cutter jaws by pulling apart the handles. Place the pipe in the cutter jaws and push the cutter's handles together so that the pipe is held in the jaws with the cutter blade directly over the mark on the pipe.
- Push the cutter's handles fully together. This will push the blade completely through the pipe, cutting it into two pieces (Fig. 11).

Pictures for Lesson 4 – Conclusion Activity

Assessment sheets and answer sheets

Assessment Sheet - Lesson One

Name: ________________________________ Date:______

Does every object float?

1. Find in the grid objects that float in seawater:

t	e	n	n	i	s	b	a	l	l
b	a	l	l	o	o	n	g	r	b
f	g	m	y	v	w	o	o	d	s
f	i	l	k	c	a	n	d	e	r
g	d	w	s	o	a	p	e	r	t
d	u	s	K	c	a	n	d	l	e
d	i	c	e	b	e	r	g	e	t
r	e	s	t	r	a	w	d	f	g
c	o	r	k	l	o	r	f	d	e
a	b	o	a	t	d	w	q	e	t

2. Little Peter, eleven years old, always thought that it was very strange for stones to, almost always, sink and cork to float. He did an experiment attempting to find an answer to his question. At first, he took a stone weighing 350 g and a piece of cork of the same weight and placed them into water. He saw that the stone immediately sank and the cork floated. He then took a stone and a piece of cork of the same size and placed them again into water hoping for a different result! What do you think happened? Is it only weight that determines an object's floatation? What do you think happened with the objects' weight when they were the same size? Was the stone or the cork heavier? What happened to their relative sizes when they had the same weight? Which one of the two objects was bigger?

………

………

3. Esmeralda claimed in front of the class that weight is the only determinant factor for the flotation of an object? Her teacher suggested that she should think her answer through and discuss it again with her the following day. Indeed, the morning after, Esmeralda, saying that she thought of particular examples from her everyday life, admitted that she was wrong! What made her change her mind? Can you think of any other properties that are of equal importance for an object's floatation?

………

………

4. Try to place the following objects in the green and blue clouds according to their size and weight. Then write down which you think are the most likely to float:

```
a huge rock, a cruise ship, an iceberg, a bunch of house
keys, a mobile phone, a pencil, a bar of soap, a wooden
table, a small metallic box full of stones, a laptop
```


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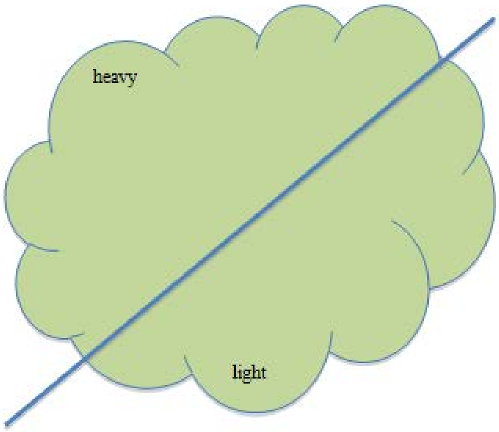
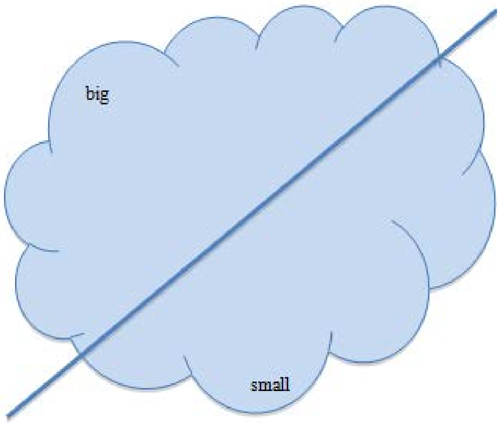




Most likely to float:

Answers - Assessment Sheet for Lesson One

Name: ________________________________ Date:______

Does every object float?

1. Find in the grid objects that float into sea - water:

t	e	n	n	i	s	b	a	l	l
b	a	l	l	o	o	n	g	r	b
f	g	m	y	v	w	o	o	d	s
f	i	l	k	c	a	n	d	e	r
g	d	w	s	o	a	p	e	r	t
d	u	s	K	c	a	n	d	l	e
d	i	c	e	b	e	r	g	e	t
r	e	s	t	r	a	w	d	f	g
c	o	r	k	l	o	r	f	d	e
a	b	o	a	t	d	w	q	e	t

(Note to the teacher: In the teacher guide is stated that at the end of lesson one, pupils must be able, among other things, to classify a range of objects in terms of their ability to float in water. This exercise addresses this issue. It uses examples taken from the children's everyday lives as well as others from their activities during lesson one. It might help pupil to think of some objects that do actually float and use them in their activity.)

2. Little Peter, eleven years old, always thought that it was very strange for stones to, almost always, sink and cork to float. He did an experiment attempting to find an answer to his question. At first, he took a stone weighing 35gr and a piece of cork of the same weight and placed them into water. He saw that the stone immediately sank and the cork floated. He then took a stone and a piece of cork of the same size and placed them again into water hoping for a different result! What do you think happened? Is it only weight that determines an object's floatation? What do you think happened with the objects' weight when they were the same size? Was the stone or the cork heavier? What happened to their size when they had the same weight? Which one of the two objects was bigger?

Recommended answer:

Once again the stone sank immediately and the cork floated. Weight is not the only factor determining an object's floatation. Volume is of equal importance. In the first case, where both the stone and the cork weighed the same, the cork was much bigger. In the second case where the objects were of the same size, the stone was far heavier than the cork.

*(**Note to the teacher:** The main goal of the first lesson is for students to realise that floatation is not just a matter of an object's weight. This exercise attempts to address this particular issue. In comparison to the next one, addressing the same thing, it is rather directive prompting the desirable answers on the part of students who are asked to visualise the differences between floating and non-floating objects in terms of weight and size (volume). At this point, students are not expected to define the relationship between the Weight of an object and the Force (Buoyancy) exerted to it when immersed into water. Rather, it is rather important to infer from his/her answer that s/he has realised that big objects, which are also light are more likely to float than small objects, which are also heavy.)*

3. Esmeralda claimed in front of the class that weight is the only determinant factor for the flotation of an object? Her teacher suggested that she should think her answer through and discuss it again with her the following day. Indeed, the morning after, Esmeralda, saying that she thought of particular examples from her everyday life, admitted that she was wrong! What made her change her mind? Can you think of any other properties that are of equal importance for an object's floatation?

Recommended answer:

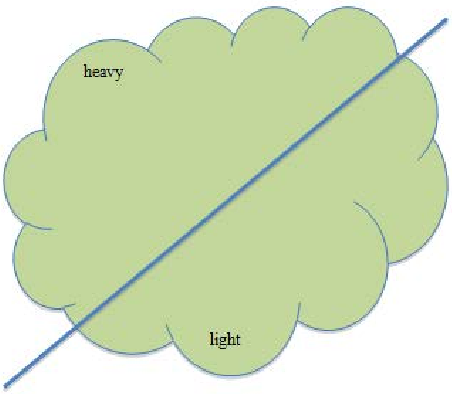
Esmeralda might have thought of boats and icebergs, which, while being very heavy can really float very well. On the other hand, she might have thought of little stones, which, while being light, sink almost all the time. In any case, an object's floatation does not depend solely on its big or small weight. Another property, which is very important for an object's floatation is its volume. That being said, it does not mean that big objects float and small objects sink, or vice – versa. It is rather a balance between the volume of an object and its weight that is decisive on whether it will float or not.

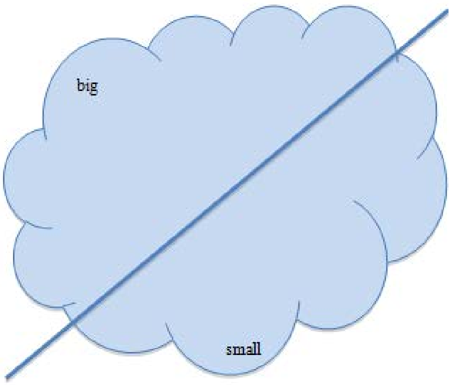
*(**Note to the teacher:** The main goal of the first lesson is for students to realise that flotation is not just a matter of an object's weight. This exercise attempts to address this particular issue. In comparison to the previous one, it calls the student to think of examples where weight is not the determinant factor of an object's floatation. That is why it is of very high value to find in his/her answer examples of both big and heavy objects (iceberg) that float and small and light objects (stone) that sink – opposite ends of a potential spectrum.*

As mentioned earlier, at this point, it is not expected from the student to define the relationship between the Weight of an object and the Force (Buoyancy) exerted to it when immersed into water. Rather, it is important to infer from his/her answer that s/he has realised that both big and small objects can float, as well as those heavy and light).

4. Try to place the following objects in the green and blue clouds according to their size and weight. Then write down what do you think are the most likely to float:

Most likely to float:
Recommended answer: Heavy objects: huge rock, cruise ship, iceberg.
Light objects: bunch of house keys, mobile phone, pencil, bar of soap, wooden table, small metallic box full of stones, laptop.
Big objects: huge rock, cruise ship, iceberg.
Small objects: bunch of house keys, mobile phone, pencil, bar of soap, wooden table, small





metallic box full of stones, laptop.
More likely to float: cruise ship, iceberg, pencil, wooden table.

(Note to the teacher: Students, by the end of lesson one, must be able to classify and evaluate a range of objects according to their ability to float in water. This exercise addresses the particular issue. It also aims at questioning the effect of weight in floating/sinking, which is also one of the main learning objectives of lesson one. Reflecting on their answer, students need to realise that not all heavy objects sink and not all light objects float. Accordingly, they manage to make classifications according to objects' properties.

Estimated time and Assessment:
The estimated time for this test is 20' to 25'. Teachers are welcome to administer the test in parts, choosing whichever question corresponds best to what they have discussed in class. Each teacher must assess the test as s/he wants depending on the work in class and the relative culture in each country.

a huge rock, a cruise ship, an iceberg, a bunch of house keys, a mobile phone, a pencil, a bar of soap, a wooden table, a small metallic box full of stones, a laptop

Assessment Sheet – Lesson Two

Name: ______________________________ Date:______

1. Is it True of False?

The reading on a dynamometer changes when an object is immersed into water	
A football sinks into water immediately	
The flotation of an object depends only on their weight	
Objects float when the buoyancy force is equal to their weight	
A stone weighs less out of water	
Boats do not sink because they sail into the sea where there is much water	
It is too easy to sink a balloon into water. We feel no resistance	
There is no upward force exerted on an object when immersed in water	

2. Make the object float!

Circle the action that will make your object float

a. A wind surfer wears her life jacket.
   She must:
   - ✓ Inflate the life jacket.
   - ✓ Fill it with water.

b. A castaway wants to send a message in a bottle.
   He must:
   - ✓ Put a cap on his bottle and throw it in the sea.
   - ✓ Leave his bottle open to fill with seawater.

c. The captain of the research submarine "Irene" wants it to resurface.
   She must:
   - ✓ Fill its water tanks with water.
   - ✓ Empty its water tanks.

d. A worker wants to move an engraved marble plate on the other side of a river:
   He must:
   - ✓ Step on it, like he does with his surfboard.
   - ✓ Lay it on a huge inflated mattress and push it on the other side.

e. You have a valuable stone in a balloon. You want them to float.
   You must:
   - ✓ Inflate the balloon.
   - ✓ Just seal the nozzle of a balloon with a paperclip.

3. Fill in the correct word:

a. There are ____ forces that act on an object, which is immersed into water.

b. The force that keeps an object floating is called ____.

c. If the weight of an object, immersed into water, is greater than the buoyancy force exerted to it, then it ____.

d. The up-thrust force exerted in an object in water _____ as its immersed volume is getting bigger and bigger.

e. The magnitude of the buoyancy force acting on an object depends on its ____.

4. Choose the correct answer (a or b) for each of the following questions:

a. The weight of the object is equal to the buoyancy force

b. The weight of the object is greater than the buoyancy force

Why does a piece of cork float? ____

Why does a huge rock sink? ____

5. Mario, an eleven-year-old boy from Italy, saw an experiment the other day where a magician threw a stone into a tank filled with water and the stone sank. Then, he watched the same stone floating when immersed into water inside a fully inflated balloon. He was surprised and wrote an e-mail to www.DrScience.com pleading for a simple answer to this magical effect. Following is DrScience's answer. However, a few of the words are missing. Could you fill them in for Mario so that he gets a comprehensible answer?

Dear Mario,

In the first case the stone's weight was _____ than the buoyancy force exerted on it when immersed into water. Consequently, the stone _____. As far as the second case is concerned, you already know that when you inflate a balloon its volume gets bigger. Accordingly the buoyancy force exerted to the balloon, which had a stone in it, _____ to the point that got _____ to its weight. Consequently, the balloon, with the stone in it, _____.

6. Circle the word that best completes the sentence:

a) On every object which is immersed in water act ___ forces.

a. two
b. three
c. four
d. seven

b) Buoyancy is a(n) ___ force, which acts on an object immersed in water.

i. upward
ii. downward

c) The buoyant force acting on an object in water depends on the ___ of the object.

i. mass
ii. immersed volume
iii. colour
iv. temperature

d) An object's flotation depends on its

i. shape and volume.
ii. volume and weight.
iii. colour and weight.
iv. temperature and volume.

e) An object will ___ if its weight is greater than the buoyancy force exerted to it when immersed in water.

i. sink
ii. float

Answers - Assessment Sheet for Lesson Two

Name: ______________________________ Date:______

1. Is it True of False?

The reading on a dynamometer changes when an object is immersed into water	T
A football sinks into water immediately	F
The flotation of an object depends only on its weight	F
Objects float when the buoyancy force is equal to their weight	T
A stone weighs less out of water	F
Boats do not sink because they sail into the sea where there is much water	F
It is too easy to sink a balloon in water. We feel no resistance	F
There is no upward force exerted to an object when immersed into water	F

*(**Note to the teacher**: This first introductory exercise attempts to address the main learning objective set for this lesson referring to the fact that on every object which is immersed in the water, an upward force acts which increases as the immersed volume of the object gets bigger and bigger. It also aims to investigate students' level of understanding about the experiments that they conducted during lesson two.)*

2. Make the object float!

Circle the action that will make your object float

f. A wind surfer wears her life jacket.
   She must:
   - ✓ Inflate the life jacket.
   - ✓ Fill it with water.

g. A castaway wants to send a message in a bottle.
   He must:
   - ✓ Put a cap on his bottle and throw it in the sea.
   - ✓ Leave his bottle open to fill with sea – water.

h. The captain of the research submarine "Irene" wants it to resurface.
   She must:
   - ✓ Fill its water tanks with water.
   - ✓ Empty its water tanks.

i. A worker wants to move an engraved marble plate on the other side of a river:
   He must:
   - ✓ Step on it, like he does with his surfboard.
   - ✓ Lay it on a huge inflated mattress and push it on the other side.

j. You have a valuable stone in a balloon. You want them to float.
   You must:
   - ✓ Inflate the balloon.
   - ✓ Just seal the nozzle of a balloon with a paperclip.

*(**Note to the teacher:** By the end of lesson two, students must realise that there is a certain condition that must be met so that an object can float. The particular exercise addresses this issue, inserting students into various circumstances where they should make use of their understanding over the issue of Buoyancy and its variables –weight and volume.)*

3. Fill in the correct word:
   a. There are two forces that act on an object which is immersed in water.
   b. The force that keeps an object floating is called buoyancy.
   c. If the weight of an object, immersed into water, is greater than the buoyancy force exerted on it, then it sinks.
   d. The up-thrust force exerted in an object inside water increases as its immersed volume gets bigger and bigger.
   e. The magnitude of the buoyancy force acting on an object depends on its volume.

4. Chose the correct answer (a or b) for each of the following questions:
   a. The weight of the object is equal to the buoyancy force
   b. The weight of the object is greater than the buoyancy force

   Why does a piece of cork float? a
   Why does a huge rock sink? b

5. Mario, an eleven-year-old boy from Italy, saw an experiment the other day where a magician threw a stone to a tank filled with water and the stone sank. Then, he watched the same stone floating when immersed into water inside a fully inflated balloon. He was surprised and wrote an e-mail to www.DrScience.com pleading for a simple answer to this magical effect. Following is DrScience's answer. However, few of the words are missing. Can you fill them in for Mario so that he gets a comprehensible answer?

> Dear Mario,
> In the first case the stone's weight was greater than the buoyancy force exerted on it when immersed in water. Consequently, the stone sank. In the second case, you already know that when you inflate a balloon its volume gets bigger. Accordingly the buoyancy force exerted to the balloon, which had a stone in it, this increased to the point that became equal to its weight. Consequently, the balloon, with the stone in it, floated.

6. Circle the word that best completes the sentence:

a) In every object which is immersed in water act ___ forces.

   a. two
   b. three
   c. four
   d. seven

b) Buoyancy is a(n) ___ force, which act on an object immersed in water.

iii. upward
iv. downward

c) The buoyancy force acting on an object in water depends on the ___ of the object.

v. mass
vi. immersed volume
vii. colour
viii. temperature

d) An object's flotation depends on its

v. shape and volume.
vi. volume and weight.
vii. colour and weight.
viii. temperature and volume.

e) An object will ___ if its weight is greater than the buoyancy force exerted to it when immersed into water.

iii. sink
iv. float

(Note to the teacher: Exercises 3-6 address the issue of the condition that must be met for an object to float –which is one of the main learning objectives of lesson two- attempting to facilitate students' understanding of it without asking them to memorise and/or reproduce definitions relative to Buoyancy. Indeed, the issue of Buoyancy is both filled with misconceptions and seems very difficult to be fully grasped by students in all its dimensions.)
Estimated time and assessment:
The estimated time for this test is 20' to 25'. Teachers are welcome to administer the test in parts choosing whichever question corresponds best to what they have discussed in class. Each teacher must assess the test as s/he wants depending on the work in class and the relative culture in each country.

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Assessment Sheet – Lesson 3

Name: ______________________________ Date:______

The Engineering Design Process

1. What are the steps that an Engineer has to follow in order to solve a problem? Put the words in the correct order !!!

    a. ask, imagine, improve, create, plan
    b. imagine, ask, create, plan, improve
    c. ask, imagine, plan, create, improve
    d. plan, improve, create, ask, imagine

2. What is the first thing that an engineer should do in order to solve a problem?
……
……
……
……

3. What does an engineer do when s/he plans the solution of a problem?
……
……
……
……

4. Is there always one solution to an engineer's problem? How must s/he think in order to choose among the potential solution to his/her problems?
……
……
……
……

5. What should happen with the size and the weight of your platform in order to float?
……
……
……
……

6. What should you do if the weight in your floating platform increases and starts to sink?
……
……
……
……

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Answers - Assessment Sheet for Lesson Three

Name: ________________________________ Date:______

The Engineering Design Process

1. What are the steps that an Engineer has to follow in order to solve a problem? Put the words in the correct order!!!

   a. ask, imagine, improve, create, plan
   b. imagine, ask, create, plan, improve
   c. ask, imagine, plan, create, improve
   d. plan, improve, create, ask, imagine

1. What is the first thing that an engineer should do in order to solve a problem?

Recommended Answer:
The first thing that an engineer should do in order to solve a problem is to think about the constraints of the problem and the criteria that must be met in order to solve it. S/he must think around possible solutions to his/her problem.

3. What does an engineer do when s/he plans the solution of a problem?
Recommended Answer:
Based on his/her ideas s/he has to decide among the most suitable solution for the problem at hand. In order to proceed to the implementation of the chosen solution s/he should first explore the materials, discuss all the possible details concerning their implementation for solving the problem, assign certain duties to every member of his/her team and if necessary, draw a clear sketch of his/her artefact –i.e. a bridge. During this step, s/he must always bear in mind the constraints and the criteria that must be met in order for his/her solution to be successful

4. Is there always one solution to an engineer's problem? How must s/he think in order to choose among the potential solution to his/her problems?
Recommended Answer:
Engineering problems may have more than one solution. S/he must always choose the one which best corresponds to the constraints regarding the solution and the criteria that must be met in order to be successful.
(Note to the teacher: Exercises 1-4 address learning objectives one and three of lesson three. Particularly, students should be aware of the EDP and the content, more or less, of each one of its steps. Additionally, they should realise that any problem may have one or more solutions that meet certain criteria.)

1. What should happen with the size and the weight of your platform in order to float?
Recommended Answer:
Small weight for its size

2. What should you do if the weight in your floating platform increases and starts to sink?

Recommended Answer:

We should use more floating materials so that its volume increases as well. The buoyancy force acting on an object depends on its volume. In case we manage to increase the buoyancy force exerted to the platform so that it equals its weight, then the platform will float again.

(Note to the teacher: In lesson two, students were not asked to memorise and/or reproduce definitions referring to buoyancy by heart. However, at the end of lesson three, after having put theory into practice they should be able to express, in black and white, the conditions that should be met in order for an object to float. Accordingly, it is one of the learning outcomes of lesson three that students must be able to use the scientific knowledge they gained in lesson two, to inform their platform design. Exercises 5 and 6 address these particular issues.)

Estimated time and assessment:

The estimated time for this test is 20' to 25'. Teachers are welcome to administer the test in parts choosing whichever question corresponds best to what they have discussed in class. Each teacher must assess the test as s/he wants depending on the work in class and the relative culture in each country.

Assessment Sheet – Lesson Four

Name: ________________________________ **Date:**_______

Understanding BUOYANCY!!!

Circle the word that best completes the sentence:

1. Buoyancy is a(n) _______________________force exerted by a liquid, gas or other fluid, that opposes the weight of an immersed object.
   a. Upward
   b. Downward
   c. Extreme
   d. Light

2. The buoyancy force depends on the _______________________ of the object immersed in water.
   a. Temperature
   b. Colour
   c. Immersed Volume
   d. Pressure

3. An object will float only when its _______________________ is equal to the applied buoyancy force.
   a. Weight
   b. Mass
   c. Volume
   d. Density

4. Objects appear to be _______________________ when are immersed in water.
   a. Lighter
   b. Heavier
   c. Different
   d. Bigger

5. _______________________ float.
   a. Heavy objects
   b. Big objects
   c. Light objects
   d. All of the above objects may

Fill in the boxes below with an S or F depending on whether you think that the object will Sink or Float.

The weight of an object is greater than the buoyancy force exerted to it ☐

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Sam inflated a life-jacket, wore it and dived into the sea	
Mary is throwing stones in the pool	
Anna immersed a fully inflated balloon with a little light stone in it in water	
The weight of an object is equal to the buoyancy force exerted to it	

What did you say?

Read the letters across in each line of the puzzle and circle those that are relevant to sinking and floating. Write these words on the lines above.

B	U	O	A	N	C	Y	I	S	A
N	Y	F	O	R	C	E	T	H	A
B	J	E	C	T	M	A	S	S	T
O	V	O	L	U	M	E	U	N	D
E	R	G	O	W	E	I	G	H	T
E	D	V	B	O	A	T	F	R	D
W	L	A	P	T	O	P	R	T	Y
W	A	T	E	R	E	R	T	V	B
A	E	M	B	V	R	W	O	O	D
P	P	H	O	N	E	V	B	T	R

1. ____________________________
2. ____________________________
3. ____________________________
4. ____________________________
5. ____________________________
6. ____________________________
7. ____________________________
8. ____________________________
9. ____________________________
10. ____________________________

Circle the odd word out:

1. buoyancy – floating – swimming – huge rock
2. engineer – plugs – buildings – bridges
3. design – ask – improve – plan – imagine – play
4. ship – submarine – floating platform – automobile
5. rock – iceberg – cork – piece of wood – boat
6. rock – metallic sphere – orange without the peel – balloon
7. technician – cables – fixing cars – designing ships
8. building houses – energy sources – engineer – printing documents

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Fill in the boxes below with a S or F depending on whether you think that the object will Sink or Float.

The weight of an object is greater than the buoyancy force exerted to it	S
Sam inflated a life-jacket, wore it and dived into the sea	F
Mary is throwing stones in the pool	S
Anna immersed a fully inflated balloon with a little light stone in it in water	F
The weight of an object is equal to the buoyancy force exerted to it	F

What did you say?

Read the letters across in each line of the puzzle and circle those that are relevant to sinking and floating. Write these words on the lines above.

B	U	O	A	N	C	Y	I	S	A
N	Y	F	O	R	C	E	T	H	A
B	J	E	C	T	M	A	S	S	T
O	V	O	L	U	M	E	U	N	D
E	R	G	O	W	E	I	G	H	T
E	D	V	B	O	A	T	F	R	D
W	L	A	P	T	O	P	R	T	Y
W	A	T	E	R	E	R	T	V	B
A	E	M	B	V	R	W	O	O	D
P	P	H	O	N	E	V	B	T	R

1. BUOYANCY
2. FORCE
3. MASS
4. VOLUME
5. WEIGHT
6. BOAT
7. LAPTOP
8. WATER
9. WOOD
10. PHONE

Circle the odd word out:

1. buoyancy – floating – swimming – huge rock
2. engineer – plugs – buildings – bridges
3. design – ask – improve – plan – imagine – play
4. ship – submarine – floating platform – automobile
5. rock – iceberg – cork – piece of wood – boat
6. rock – metallic sphere – orange without the peel – balloon

7. technician – cables – fixing cars – designing ships
8. building houses – energy sources – engineer – printing documents

Estimated time and assessment:

The estimated time for this test is 20' to 25'. Teachers are welcome to administer the test in parts choosing whichever question corresponds best to what they have discussed in class. Each teacher must assess the test as s/he wants depending on the work in class and the relative culture in each country.

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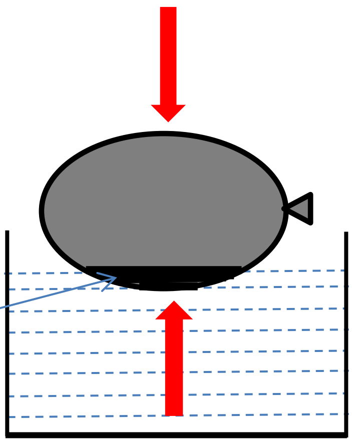
Science notes for teachers about buoyancy – sinking and floating

Some key science concepts involved in Lesson 2
• **Weight is a force** • **Forces come in pairs (weight and buoyancy)** • **Weight for size** • **Balanced forces**

Buoyancy
In order to study the concept of floating and sinking it is helpful to consider which forces act on an object that is placed into a fluid[2]. We all know that gravitational force (weight) acts on every object on Earth. As a consequence, the same applies to an object that is immersed in water. However, in this case another force called buoyancy (sometimes referred to as upthrust) also acts, which is exerted on the object by the water and has an upward direction. When these forces of weight and buoyancy acting on the immersed object are equal (balanced), the object floats. This is illustrated in Figure 1 below. The balloon only displaces a small amount of water because it is a light object.

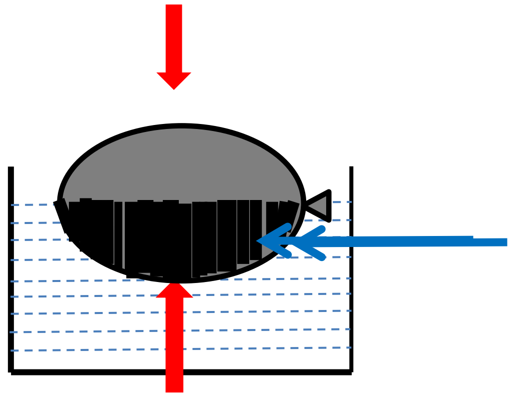
Figure 1. Weight of balloon acts downwards



These forces can be experienced by immersing an inflated balloon (Lesson 2 activity 2.3) in a tank of water (Figure 2) and pushing down slowly with your hand on the top of the balloon. As the balloon is pushed further down, more water is pushed out of the way (displaced) and the 'push back' force (buoyancy) of the water acting on the balloon increases. This is considerable and pupils are often surprised at how much force is exerted by the water. The more water is 'pushed out of the way', the more the water pushes back. This qualitative experience of feeling the increase in force is important. It is a useful way of introducing the idea that there is a direct link between the amount of an object's immersed volume and the buoyancy force exerted on it. That is, as you push the balloon further down, a greater proportion of its volume is immersed in the water. This pushes more water out of the way causing an increase in the push back from the buoyancy force. There is a direct ***quantitative*** relationship between the amount of water displaced by the object and the resultant buoyancy forces exerted on it by the water.

[2] Fluid: Anything that flows; in particular, any liquid or gas

Figure 2. Pushing the balloon in the water increases the downward force resulting in a greater volume of water being displaced

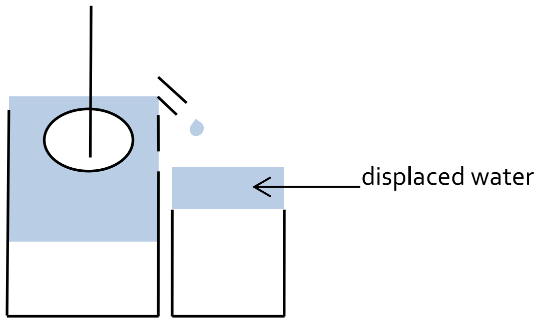


This quantitative relationship is an important one and is explained by Archimedes principle. (The interesting story about Archimedes is detailed in the section at the end of the science notes and is an optional enhancement activity).

One way of thinking about this is to consider an explanation in terms of ***weight for size***. This is explored in Lesson 2 activities 2.3 and 2.4. A key idea here is to recognise that because heavy objects exert a large force (weight is a force) on the water there needs to be a large buoyant force exerted on the object to keep it afloat. The only way a large buoyant force can be created is if there is a lot of water pushed out of the way so that it can push back with a large force. In order to float, a heavy object needs to be a large size to be able to push a lot of water out of the way. Such objects are heavy, but also large. They are relatively ***light for their size***. Conversely, an object that is heavy for its size will sink because the weight (force) acting on the object is greater than the buoyancy (force); the object's size isn't sufficient to push out enough water. We would say such objects are ***heavy for their size***. This is not only a difficult idea but also a counterintuitive one. The metal paper clip, for example, is made of the same material (metal) as a huge oil tanker. The paper clip, which weighs less than one gram sinks, and the oil tanker, which could weigh up to 100, 000 tons floats. We would say that the paper clip, although ***very light, is heavy for its size***. The oil tanker although ***very heavy, is light for its size.***

The forces acting on floating objects are equal. For fully submerged objects, the weight force is greater than the buoyancy force. The water still exerts some force on the submerged object but not enough to keep it floating. An object that is fully submerged in water will 'push out' (displace) a volume of water equal to its own volume. It is therefore a good way of measuring the volume of irregular objects because you can measure the volume of water displaced in different ways (figure 3).

Figure 3. When an object is submerged, it pushes water out of the way. It displaces the water. The volume of water displaced is equal to the volume of the object



An interesting story relating to these ideas is that of Archimedes and the formulation of Archimedes Principle. This is described at the weblink below:
http://www.longlongtimeago.com/llta_greatdiscoveries_archimedes_eureka.html

For a sunken object, the volume of displaced fluid is the volume of the object. For a partially immersed object, the volume of the displaced fluid equals the object's weight. This could be summarized as:

Buoyancy (force) = Weight (force) of the volume of the displaced fluid

This *balance* of forces makes the object floats.

Weight (force) = Buoyancy (force) → Flotation

When placed in water, if an object's weight is greater than the buoyancy force (at this point) then the object will move downwards. When the object is fully submerged and still its weight is greater than buoyancy, then the object will continue to sink.

Weight (force) > Buoyancy (force) → Sinking

It is very important to point out, once again, that ***the buoyancy force acting on an object depends on the volume of the object.*** So, small objects displace small amounts of water and the buoyancy force acting on them is small. Even though they are light, such objects can still sink, as in the example of the metal paper clip. However, large objects displace large amounts of water and the buoyancy force acting on them is larger than the one exerted on small objects. Even though they are heavy, as in the example of the oil tanker, such objects can still float.

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Some pupils' ideas of science concepts about sinking and floating

Children's thinking about the natural world comes from their everyday experiences. They may not represent the established current scientific view but they usually contain sensible reasoning based on observation and interaction. Offering opportunities for children to challenge their thinking through activity is more likely to shift their perceptions than telling them facts. However, this presents a significant pedagogical task. It is extremely demanding for learners at all levels and ages to accommodate new ideas about a particular phenomenon, especially when these seem to contradict common sense reasoning. Although through research we have some insight into the ideas pupils are likely to have in particular conceptual domains in science, often, pupils have difficulty in articulating their thinking so there is a need to exercise some caution in making assumptions about their reasoning. This highlights the importance of providing opportunity for children to discuss their thinking.

The following points provide opportunity for the teacher to discuss further with pupils their ideas.

- **Light/small objects float, heavy/ big objects sink**

It is intuitive for pupils to think that heavy objects sink and that light objects float even though they will have experiences that contradict this. It is important to recognise that even when practical investigation provides clear evidence to challenge this idea it is so intuitive that learners (including adults) often focus on this attribute in predicting which objects will float when placed in water. This is not surprising but points to the need to structure practical experiences to allow for discussion and thinking about why weight alone is not the determining factor. The problem is complicated because it requires consideration of two concepts simultaneously, weight and size. The weight of an object in relation to its size is the key issue because of the reasons stated above and underpins the activities designed in lesson 2 that provide opportunity for pupils to think about this. It is likely that pupils will think that a small object that is light such as the paper clip will float and that a relatively heavy and large piece of wood will sink. Such thinking is perfectly sensible but fails to take into consideration ***weight for size***.

- **Hollow objects containing air in their structure float**

This is a common and sensible idea and in most cases, where objects float, air is often involved. It might be better to think about this in terms of air being a material that is good for making for making an object light for its size. Other materials (usually gases) are good for this to, but air is in ready supply. Using a gas to increase the size (volume) of an object is a good way of changing the weight for size of an object, making it light for its size. Air does not weigh much so it does not increase the object's weight significantly but it can make the object a lot bigger changing its weigh for size. This idea is explored in lesson 2 activity 2.3. The same idea is used in submarines, which alter their weight, by taking in some water to make them heavy for their size; this enables them to dive under the surface of the water. In order to float back to the surface, they replace this water with air to make them light for their size.

- **Things with holes sink**

The idea that objects with holes in them sink probably comes from experiences of playing with water pouring it into objects with holes in them to make them sink and watching films about ships that have had their hull pierced sink (e.g. Titanic). This can be explored through observing what happened to different objects with holes in them when placed in a tank of water. Not all sink and this provides opportunity to discuss this with pupils. The key point is that water needs to enter through the hole and be contained within the object to make it heavy for its size and sink. Where the water is not contained, the weight for size will not be significantly changed and in some instances this means the object will remain floating. This is the case with a piece of wood or candle wax.

- **A large amount of water makes things float or the buoyancy force exerted on an object depends on the amount of water in which the object is placed**

Pupils sometimes think that the deeper the water, the better things float. This idea is likely to come from experiencing pressure increase with depth such as diving into deep water. However, this increased pressure with depth does not keep things afloat, a sinking ship goes straight to the ocean floor. An object will float provided there is sufficient depth and space for it not to be touching the base or sides of a tank or pool.

- **Soft objects float, hard objects sink**

This is clearly not the case and can be explored through investigating a range of objects (balls of different materials are a good way of doing this). The idea probably comes from confusing an object with a material (see below)

- **Floating/sinking of objects only depends on the material of which they are made.**

This is often to do with confusing an object with a material. The example of the paper clip and the oil tanker illustrate the point. Metal as a ***material*** sinks but can be made into an ***object*** that floats'

- **Flat things float**

A common idea is that floating occurs because of surface contact and that because of this, surface area is the causal factor that determines floating. This probably comes from the thinking that the larger the contact area the more the water is able to push on the surface. However, this is not where the buoyancy or upthrust force derives from (except in the very special case of surface tension where the object is so light it does not break the 'skin' of the water surface e.g. as in certain insects such as a pond skater). This idea can be explored using flat shapes that sink but it is important to allow time for the pupils to discuss their thinking.

- **Object with geometric shapes float, while others sink; floating and sinking depends on an object's shape**

The shape of an object is often identified as a determining factor in floating probably because boat shaped objects float. This can be investigated easily. Clearly, objects that are not boat shaped float and objects of different shapes sink. A paperclip for example sinks no matter what shape you bend it into any shape it still sinks.

- **When a part of an object is outside the water, the object is considered to be floating. When all parts of an object are inside the water, the object is considered to be sinking.**

This is a matter of how we use the term "floating" in science. It must be made clear to pupils that floating is a state in which the weight of the object equals the exerted (by the water) buoyancy force and that is something that can happen regardless of where the object is located in relation to the water's surface e.g. a fish is floating even if it is below the water's surface.

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A Glossary of terms related to this unit

Buoyancy
The ability of a fluid to create an upward force on an object placed in it. This force (buoyancy) is related to the immersed volume of the object.

Classify/Classification
The act of distributing things into classes or categories based on specific criteria or common properties. For instance, the classification of matter into gas, liquid and solid state.

Dynamometer
An apparatus (device) for measuring force. The function of this devise is based on the elongation of the dynamometer's spring.

EDP
Abbreviation for the term "Engineering Design Process". The Engineering Design Process is a formulation of a plan or scheme to assist an engineer in solving a problem.

Engineer
A person who uses their creativity and understanding of mathematics and science to design things which solve problems.

Experiment
The act of conducting a controlled test for the purpose of discovering something unknown or for testing a principle

Floating
Floating is the state in which, when an object is fully or partially immersed into water and it's weight equals buoyancy. An object can float either on, or below the water's surface.

Force
Forces make an object to move, stop, change direction or shape.

Gravity
The attractive force that the Earth exerts to all objects.

Observation
The act of noting and recording something, such as a phenomenon, and undertaken with or without instruments.

Ocean Engineer
An engineer concerned with solving problems related to engineering challenges in an ocean environment.

Phenomenon
An observable event.

Physical Principles
The procedures and concepts we use to describe the world around us.

Physical Properties
Are properties that can be observed or measured without changing the composition of matter. Physical properties are used to observe and describe matter.

Physical science
Physical science is concerned with describing and explaining physical phenomena.

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Science Investigation Process
The Science Investigation Process is a set of steps and techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge.

Sinking
Sinking is the state in which, when an object is placed in water its weight is greater than buoyancy. As a consequence the object moves towards the bottom.

Variable
A quantity that can be changed or vary, taking on different values. When we are performing an experiment or trying to solve a problem, we need to distinguish the involved variables between two different types, independent *and dependent*.

Variable, *Independent*
Independent variables are those quantities that the person who performs an experiment chooses to change deliberately in order to observe how this change affects the result.

Variable, *Dependent*
Dependent variables are the quantities that are affected/changed due to the variation of the independent variables (see above). For example if our experiment has to do with floating/sinking objects, the independent variable can be the weight, the volume, the colour, the temperature, etc. of the object. The dependent variable is the depth that the object reaches.

Volume
This is the amount of space that matter takes up.

Weight
A measure of the force of gravity upon an object

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