Ship shape!
Teacher's Notes

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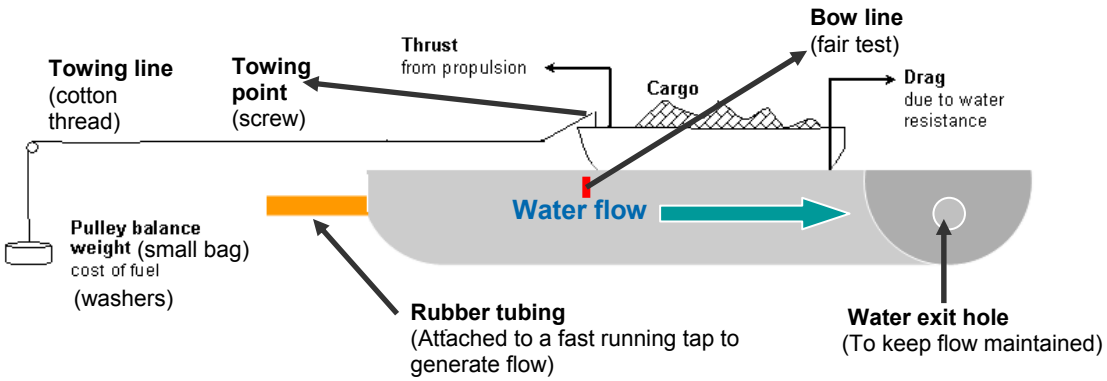
Preface:

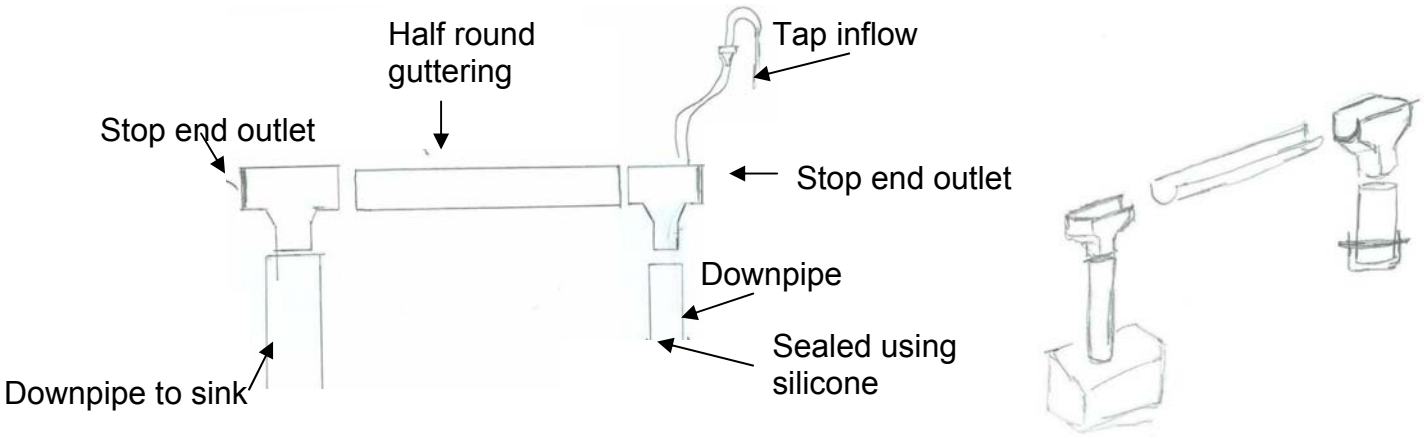
Ship shape is an activity designed to set principals of stability, buoyancy and drag into practice using the example of ship design. This exercise gives pupils experience in how physics principals are applied to the real-world; in particular the shipping industry itself and allows for a degree of enquiry-based learning.

The piece of equipment used to test resistance of model ships, known as a 'towing tank', will need to be made in advance of this lesson. Your school technicians should be able to create something similar to the model presented on the *ship-shape* slideshow. This can be made in one of several ways.

Essentially, you will need to set up a unit with a constant water flow running through it (to simulate water resistance). This can be done using a closed piece of home guttering with two holes either side; one side to be attached to a piece of rubber tubing (with a seal to prevent leaking) and a tap, and the other to drain into a sink. The design is presented in the diagram below:



An alternative design is to use two stop end outlets (also used in guttering designs) attached to two pieces of downpipe; one sealed with a tap running into it, and the other leading directly into a sink. The design for this is presented below. The former design has proven most effective during trials. If your school can get hold of a re-circulating water channel this of course would be the ideal option!



Audience:

Key Stage 3 pupils - all years

Length:

3 hours if a practical element is included (plus technician time to design ad build the 'towing tank'). If not 1 hour for the theoretical element.

Learning Objectives:

- To give pupils an appreciation for the value of the shipping industry in our everyday lives and the role design principals relating directly to theoretical physics links to this.
- To provide pupils with real-world application of the physical principles of buoyancy, stability and drag to the example of ship design and building.
- To give pupils practical experience in applying theoretical physics into practice in a way relevant to real world industrial practice.

Running the activity:

Starter* – 20 minutes*: Print out copies of the *watery_dominos* worksheet in the starter folder of this resource. Cut out and laminate the resource and encourage pupils to play the game in mixed ability groups to generate teaching and learning amongst peers.

***Main* – 2 hours and 30 minutes:** Present the *ship shape slideshow* using the notes provided on each slide. Note if a practical element is not being included, or if the design of your towing tank is substantially different to the examples provided, you may need to alter some of the slides provided.

In order to undertake the practical activity associated with this resource pupils will need to create model ships. This can be carried out in a complementary Design and Technology lesson prior to this resource being used or incorporated into the lesson itself. Pupils should create their ships in teams and the test element be introduced as a competition between the groups.

The simplest way to make the ships is to purchase some home insulation polystyrene foam. This material is high density but still easy to mould and shape using hack saws and other school approved design and technology equipment and is therefore perfect for modelling ships quickly and easily. The material is relatively cheap and can be purchased under the following link:

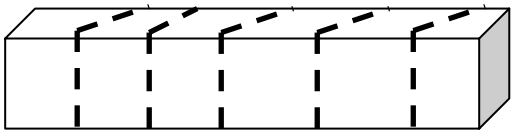
http://www.diy.com/diy/jsp/bq/nav/nav.jsp?action=detail&fh_secondid=9374253&fh_view_size=6&fh_start_index=6&fh_location=%2f%2fcatalog01%2fen_GB&fh_search=kaunf&fh_eds=%c3%9f&fh_refview=search&ts=1220944345860&isSearch=true

To make the model ships follow the instructions below. Once the strips and blocks have been cut its over to the pupils to cut out and shape their ships. Instructions for pupils are provided in detail on the *ship-shape slideshow*. These model ships will be useful for the rest of module A so can be retained for future use.

To make the model ships pupils will need:

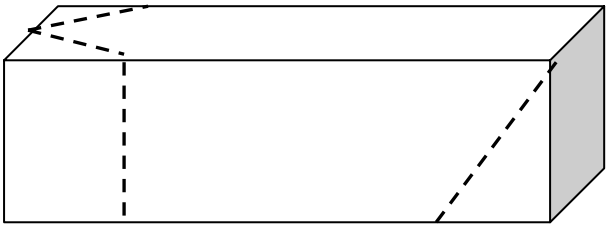
- Junior hacksaws
- Stanley knives
- Flathead screwdrivers
- Sand paper (various grades)
- Waterproof markers
- Safety rulers
- Nuts (various sizes) to function as cargo

Steps: (before class)
1 – Cut the foam board into strips of equal width. The diameter is up to you, but ensure they fit in your towing tank water channel. Lengths can vary, to give pupils the opportunity to enquire about whether long or short ships will be more efficient when tested. Longer ships may carry more cargo but they also generate more drag.

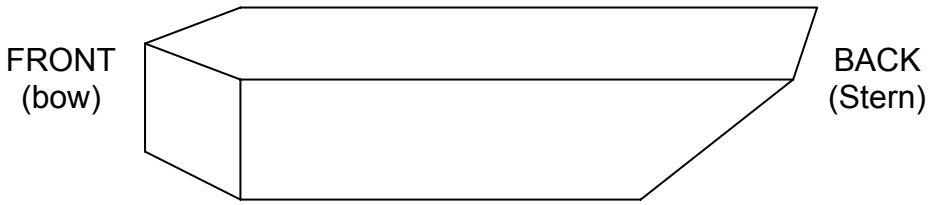


Steps: (in class)
1 – Provide pupils in groups with one cut foam block, one junior hacksaw, one Stanley knife, some sandpaper, a flathead screwdriver, a safety ruler and a waterproof marker.

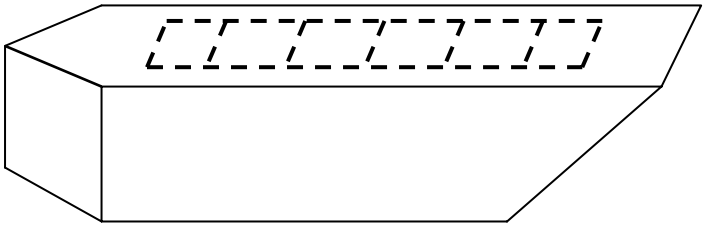
2 – Ask pupils to draw onto their foam strips the shape indicated below (or they could select their own shapes):



3 – Ask pupils to cut boats from their foam blocks using the safety ruler and the junior hack saw so they have something that looks like this.



4 – Pupils now need to make their cargo hold. Ask pupils, with their marker pens, to draw a box on the top of their ships similar to the one below. Under supervision, ask pupils to use their Stanley knives to cut along their shapes and also to score across the box too. This will help to remove the material during the next stage.



5 – Using the flathead screwdriver ask pupils to press the end of the screwdriver into the scores made on their model ships. By levering the screwdriver at the same time, sizable chunks of the cargo hold should come up in one go. Repeat the process until there is a hollowed out cargo hold approximately half the depth of the ship.

6 – Using the sandpaper, round-off the ship on the outside to make it smooth. Pupils should also sand flat the inside of the cargo hold. Once this is complete, pupils could decorate and name their ships.

To test ships for stability, you will need:

- Plastic trays filled with water
- Metal nuts (cargo)

As well as the towing tank, for testing resistance you will need:

- Screws (to act as the towing point on the end of the ship)
- Washers (to act as money in the pulley system)
- Cotton thread (to act as the tow line)
- Small plastic bags (attached to the opposite end of the tow line to put money in)
- Tape (to attach the small plastics bags to the towing line)
- A top pan balance (accurate to .1 of a g) to weigh cargo

Record pupils results on the whiteboard or the results table provided on the Ship-shape presentation. Ask pupils to weigh their cargo and count the number of pennies required to generate ship thrust. Encourage pupils to work out the calculation for themselves and tell you which ship is most efficient (the ship that carries the most cargo for the least amount of pennies) and therefore who has won.

Plenary* – 10 minutes*: .Line up all the ship designs in order of most efficient to least efficient. Discuss as a class why you think the most efficient ship did actually win. Discuss its design attributes in relation to the other ships using theory from the ship-shape presentation. This will help consolidate pupils' knowledge.

Where it fits in:

Module-based curriculum

1. Unit 7K- Forces and their effects
- Identify the origins of friction, water resistance, up thrust and weight and describe situations where these forces act.
- Factors affecting frictional forces

2 – Unit 9G – Environmental chemistry
- Ways fuel consumption can be usefully limited

3 – Unit 9K – Speeding up
- Relationship between forces, including balanced forces, on an object and its movement
- Effects of water on speed and how streamlining reduces these effects
- In order to increase speed without increasing thrust, resistance or drag has to be reduced
- Why streamlining is important
- Fuel consumption greater at higher speeds to overcome resistance
- Investigate the effect of shape on movement through a liquid

2 – Unit 9L – Pressure and moments
- That a turning effect is referred to as a moment

Enquiry-based curriculum

1.1 – Scientific thinking
1.1a – Using scientific ideas and models to explain phenomena and developing them creatively to generate and test theories
1.1b – Critically analysing and evaluating evidence from observations and experiments

3.1 – Energy, electricity and forces
3.1b – Forces are interactions between objects and can affect their shape and motion

3.4 – The environment, Earth and universe
3.4c human activity and natural processes can lead to changes in the environment

4 - Curriculum opportunities
4c - Use real life examples as a basis for finding out about science
4f – Use creativity and innovation in science and appreciate their importance in enterprise