NATIONAL SCHOOL
SAILING ASSOCIATION

TOWING TANK EXPERIMENTS

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TOWING TROUGH EXPERIMENTS IN THE CLASSROOM

by Jim Exley

The enthusiasm of our pupils is obvious during actual sailing but we all look for ways to bring this back to the classroom.
One means of relating sailing to school science is via model tests, although the possible problems of expense and complication in providing a suitable tank and propulsion may discourage attempts to do so.
There are, however, ways around these; for example, cheap building materials will provide the tank, and gravity will do the towing rather better than a motor. The cost of the project will thus be minimal.

TOWING TROUGH

This is plastic guttering, easily obtainable from DIY store or builders' merchant. Choose the flat- bottomed type for stability. It is available in various lengths (short lengths can be joined with standard fittings), and you will need two stop-ends, unless you improvise these.

TOWING LINE

Nylon monofilament fishing line of about 0.5 kg (1 lb) breaking strength is strong enough, and smooth.

WEIGHTS AND HANGERS

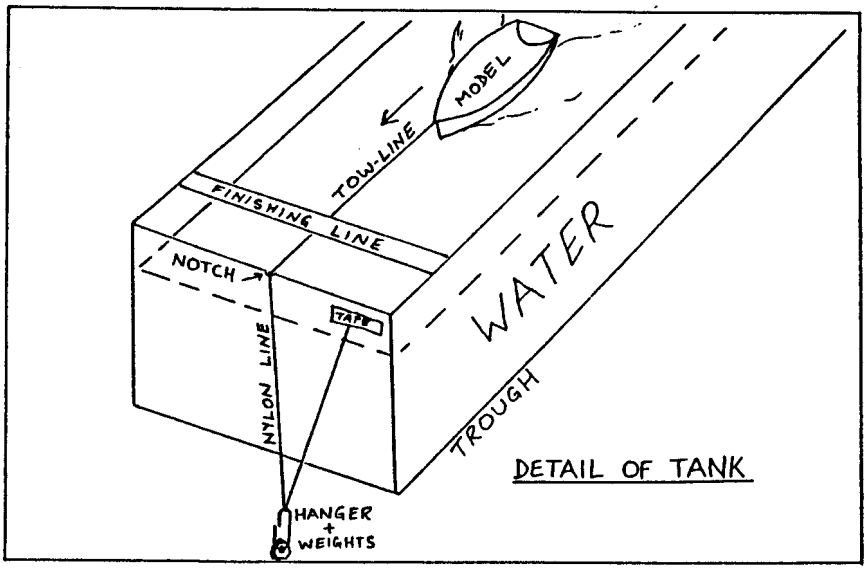
A bent paper-clip and steel nuts are cheap and effective, though proper laboratory weights can be used. 5/8" AF or 15 mm nuts are about the right size

MODELS

Small plastic boats will do for a first investigation, or perhaps a squeezy bottle cut lengthwise, but for serious investigation you should aim to fix some of the possible variables, such as displacement, or length. Hulls can be carved from blocks of balsa, or expanded polystyrene, and ballast added to make the weights equal. It is worth going to some trouble to make accurate and attractive copies of existing hulls; 15 cm (6") is the maximum length of model hull suitable for the trough depth. More information on the construction of models is included atthe endof this publication.

TIMING

Since speeds are relatively small, it is quite accurate enough to use a stop-watch; many pupils have these on wrist-watches even if you are still a traditionalist! (Note in 2012 Now they have them on their mobile phones and do not have wristwatches - this is digital watches arriving)



MODEL BUILDING

The simplest method is to cut out layers of 6 mm (1/4") balsa wood, glueing them with balsa cement, which is quick-drying and waterproof. The hull lines can be duplicated and each shape cut out and stuck to the wood, or traced through using carbon paper, or pricked through with a needle and the points joined up to produce a smooth curve.

A balsa knife and-.a razor saw are recommended for cutting out the layers of the sandwich; these are widely available from modellers' shops. Once the glue is dry, the model is then carved, sanded until smooth, and painted to waterproof it.

Aerosol cans of car paint from car-accessory shops are colourful and simple to use. It is worth going to some trouble to obtain an attractive and well-finished model. You must also remember a bottle of champagne for the launch if you are a true traditionalist.

THE TRIALS

A series of trials should be run, keeping the boat displacements (weights) the same. The weight used to propel the boat should not be too great, since the faster the run, the more significant any errors become; the boat should certainly not be allowed to plane.

If possible, every pupil should do at least one run with every boat, so that they are all involved and errors are reduced. When results for each boat have been tabulated, and averaged, they should be discussed fully; who got the finishing order right, and what were the reasons behind this order.

Factors to look for include:-

Which boat was widest?

Which was most deeply submerged

Which will have to push aside least water, and which most?

Which boat will thus meet least resistance, move most easily and go fastest under a given power/propelling weight?

It would be possible to introduce the concept of projected area - the sizes of frontal areas -and these could be worked out and compared.

As a natural follow-up, if time allows, why not have a competition to produce the fastest hull, or the slowest?

Although some limitation on size may be desirable for comparison of hull shapes, it could also be instructive to see how hull length and beam affect the performance by scaling-up the plans, while hollowing the hull to keep displacement the same. This last idea will mean the water-line will change, so extra interpretation of the results may be needed.

INVESTIGATIONS

At its simplest, study how the speed of a chosen hull compares with the towing force, while as an extension, different hulls can be compared. Differences in the shape of graph produced can be investigated with further experiments, and hypotheses tested.

Hull shapes that could be tried include round-bilge, single and double-chine, flat-bottomed and cathedral form. When comparing hull shapes, it is only valid if both weight and waterline length are the same for each hull. Fairly large changes are needed to give much difference between hull types.

Another possibility is to investigate the effect of crew weight on speed by loading the boat with weights, and an extension could investigate

how the distribution of weights affects the speed (the hanging over bow, and lounging in stern tendencies). Heeling effects could be simulated by off-centre weights.

METHOD

The trough must be set up at least as far above the floor as half its length, since the towing line is pulled downwards in a loop by the falling weights. Take care to select an area where a water spill will not upset caretakers and others, who may not see the importance of the research. The towline, a little longer than the trough, is attached to the boat by tape or a pin. The other end is taken over a shallow notch in the end of the trough, and is taped to the edge, to leave a small loop. The hanger with weights is hooked over the loop (bight?), and released when the pupil is ready to start timing. It is better for one pupil to do both these operations as it is more accurate.

SHAPELY HULLS

Towing Trough Experiments
on Hull Proportions
by Jim Exley

The chief object of this experiment is to get the pupils to think about the factors which affect water resistance, and thus to understand some of the reasons why one boat is faster than another. There are more general lessons to be learnt about basic scientific method.

The construction and mode of use of the towing tank is described at the front of this booklet.

MODELS

A set of three models is suggested. Directions for the construction of suitable boats are included in the centre pull-out sheet,. and how to make them is explained below. Naturally, if suitable hulls are already available they would serve instead.

Suitable sizes would be:-

BOAT A	150 mm long	75 mm beam
BOAT B	150 mm long	57 mm beam
BOAT C	200 mm long	57 mm beam

INTRODUCTORY WORK

Pupils should be encouraged to discuss the reasons why one boat might be faster. Colour can be rejected as a reason for speed, though I have known adults who believed that red motor-cars, especially those with speedometers marked in k.p.h., were always fastest.

Everyone should predict a finishing-order, since this also produces thought, involvement, and therefore interest

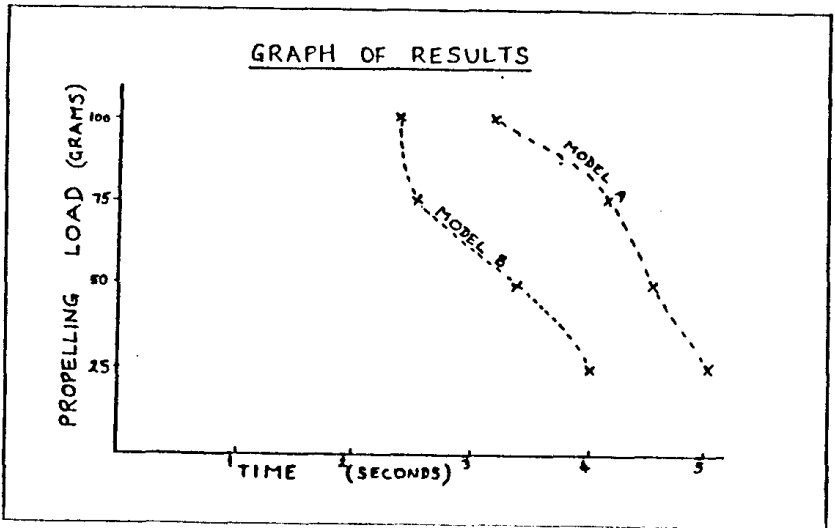
Since times are fairly short, each pupil can get a set of values, which can then be averaged for greater reliability. A "finishing" tape across the tank will stop the model crashing into the end, and act as a timing point.

Asking the pupils for their predictions before the trial encourages thought, and stimulates interest, while making an informal "book" on the . results may appeal to their competitive instincts!

RESULTS

Graphs of speed (or time taken for the test) against the towing load can be drawn from sets of 3 or more averaged readings for each hull-type studied, with each set of points plotted in contrasting colours. Another graph could be speed (time taken) against towing load or different weights in the boat, to investigate the effect of crew weight.

Whatever the chosen quantities, some conclusion should be possible, even if only that the apparatus is not sensitive enough for those particular differences to be measured. It is unlikely that tank testing of this type will reveal a revolutionary new hull shape, but get testing!



BOAT MODELS FOR TOWING TESTS

For each hull, cut out one of each of shapes 1 to 4, stick together, and sand smooth