UNIT 15 *Variation* Activities

Activities

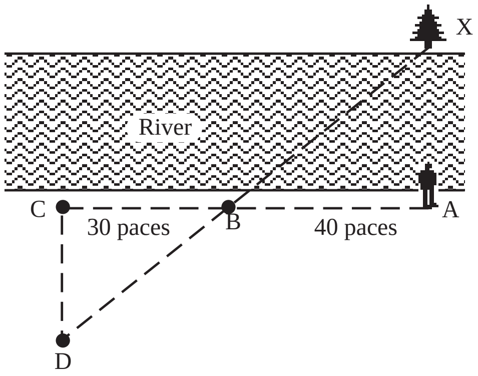
ACTIVITY 15.1 *How Far Away?*

Pace Length Before you attempt the tasks below you must first find the length of your pace. To do this, it is best to walk at least 10 paces, measure the distance, and divide by 10.

Distance

It is useful to be able to judge distances, and it is often not as difficult as you might think. Suppose, for example, you want to estimate the distance across a river. You can follow the procedure below:

- Find a landmark, say X, on the opposite bank from you, at A.
- Walk along your side of the river for, say, 40 paces, and mark the point with a stick, B.
- Walk on 30 paces to C, and walk inland to a point D so that DBX are in a straight line.
- Count the number of paces taken between C and D.



Problem 1 What can you say about triangles DCB and XAB?

Problem 2 What is the ratio $\frac{XA}{CD}$? This can now be used to find XA.

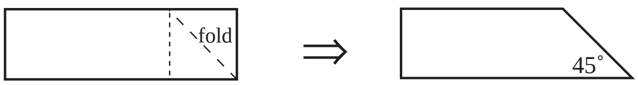
Height

There is a similar method of estimating the height of a building or tower. You follow the procedure below, but first you need to make a *sight gauge*.

To Make a Sight Gauge

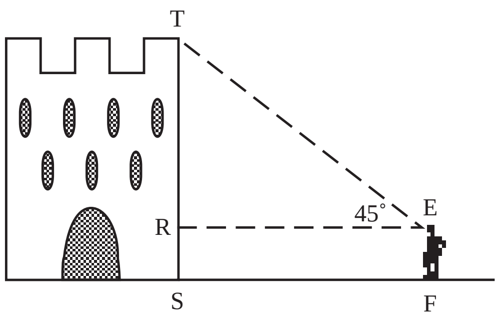
Fold a strip of card as shown opposite.

This gives a $45°$ angle.



- Starting at the foot of the tower, count the number of paces as you walk away.
- Stop walking when, looking along your sight gauge, you can see the top of the tower.

(Make sure that you keep the gauge level.)



Problem 3 Why is $TR = RE$?

Problem 4 Explain why the height of the tower $= RE +$ your height.

Task

Try out both these methods, and judge their accuracy.

Extension

Discuss other ways of estimating distances.

ACTIVITY 15.2 *Fishing Competitions*

A fishing club, for conservation purposes, encourages members to release their fish immediately after the fish have been caught.

They run competitions with prizes not only for the person who catches the *heaviest* fish but also for the person who catches the *greatest total weight* of fish during a specified time.

One of the problems in awarding the prize in the latter competition is that each fish caught has to be weighed! Although each competitor could be issued with a weighing machine, it is easier to measure the *length* of each fish caught and use this as the basis for awarding the prize.

This table gives the results for 4 competitors after a day's trout-fishing competition.

Competitors	*Lengths of fish caught*				
A	24.1	34.7	31.2		
B	47.6	23.2			
C	12.5	21.3	27.9	22.5	14.7
D	26.0	43.1			

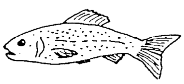
Problem 1 Assuming that weight and length are in proportion, which competitors win the prizes for the heaviest fish and for the greatest total length?

Is this a fair way to award the prizes?

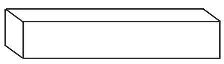
In fact, if we double the length of the fish, then, assuming that the fish are all in proportion (being all of the same type), the width and height would also double. This means that

$$\text{volume is increased in ratio of } 2 \times 2 \times 2 = 8$$

Another easy way of expressing this is to assume that weight is proportional to the *cube* of the length:



$$w = k\,l^3$$



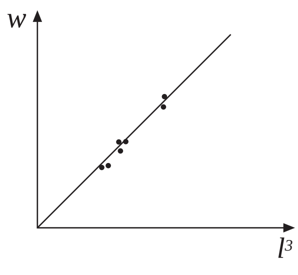
So if l is doubled, $w = k(2l)^3 = 8kl^3$; the weight is multiplied by 8. Test this model with the following experimental data.

These data were collected by one competitor during a day's fishing competition.

length (cm)	36.3	31.3	43.1	31.6	44.4	35.3	31.6	36.3
weight (g)	770	490	1170	490	1400	650	450	740

Problem 2 Plot w against l^3 on a graph, choosing suitable scales.

Draw a straight line of best fit through the data points and use it to find an appropriate value for k (the gradient).



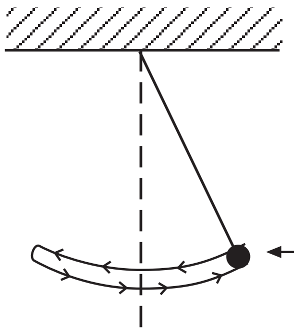
Problem 3 Use the new model to estimate the weight of fish caught by each competitor.

Who are the winners now?

ACTIVITY 15.3 *Oscillations*

Have you noticed that if you go faster on a swing, you will climb higher, but the time of your complete swing (the *period of swing*) will remain the same?

Find out if this is true with these simple experiments and then try to find what *does* determine the *period of swing*.



Experiment 1

Take a piece of string (about 1 m long) and fix a heavy object to one end. Suspend the object from the ceiling or a beam and then let it oscillate (swing) as shown in the diagram.

Find its *periodic time*, i.e. the time of one complete swing.

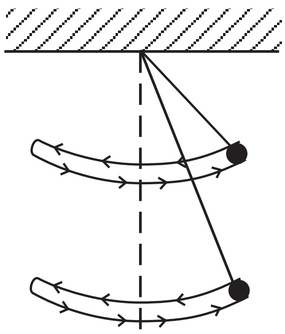
For accuracy, it is better to time 10 swings using a stopwatch and divide the total time by 10.

Experiment 2 Repeat the experiment, but this time let the object have a wider swing, either by pulling it further back from the vertical before you release it, or by giving it more push. What do you notice about the periodic time?

Experiment 3 Repeat the experiment with different release points. What do you notice about the periodic time?

You will see in the next experiment how the periodic time depends on the *length* of the pendulum.

Experiment 4 Repeat the experiment but use different lengths of string, (e.g. 0.5 m, 1.5 m, 2 m).



Problem The periodic time, T, and the length of pendulum, l, are related by the equation

$$T = k\sqrt{l}$$

where k is a constant.

Plot a graph of T against $\sqrt{l}$ for your experiment results.

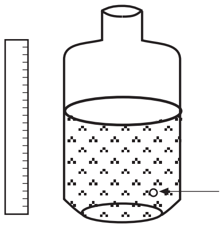
Draw a straight line as close as possible to your points, and use this line to estimate the period of a pendulum of length 3 m.

Experiment 5 Repeat the experiment with a pendulum of length 3 m, and see how close you are to your predicted answer.

ACTIVITY 15.4 *Leaking Bottles*

Take a plastic bottle and make a small hole near the bottom. Fix a scale (in cm) on the side of the bottle so that you can measure the height at any time.

Experiment 1



Stand the bottle beside a sink, fill with water to a specified level and then note the time as each cm decreases in height.

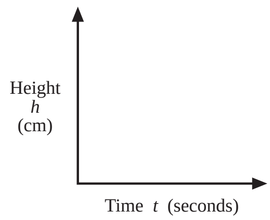
Set the data in a table as shown below.

Height (cm)	12	11	10	9	8	7	6	5	4	3	2	1
Time (seconds)	0	7	17	29	42	54	68	84	101	121	147	180

Repeat the experiment several times and then take the *mean* value.

Data Analysis

Problem 1 Plot *your* values of height, h, against time, t.
Is there a linear relationship?

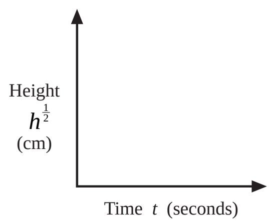


Problem 2 Plot $h^{\frac{1}{2}}$ against t.

Can you deduce a formula of the form

$$h^{\frac{1}{2}} = A - Bt$$

for suitable values of A and B?



Experiment 2

Take a bottle of the same type and make a hole of a different size, but at the same height as before. Repeat Experiment 1. Try the experiment several times with holes of different sizes.

Problem 3 Does the formula $h^{\frac{1}{2}} = A - Bt$ still hold?

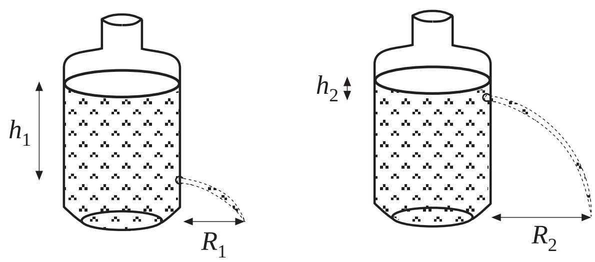
Experiment 3

Use similar bottles filled to the same height and note the *range*, R, of the jet for equally sized holes at different distances below the water level.

Data Analysis

Problem 4 Plot R against h.

What does it show?



ACTIVITY 15.5 *Fitting the Graph*

Choose the best graph to fit each of the eight situations described below. (Particular graphs may fit more than one situation.) Copy the graph, label your axes and explain your choice, stating any assumptions you make. If you cannot find the graph you want, draw your own version.

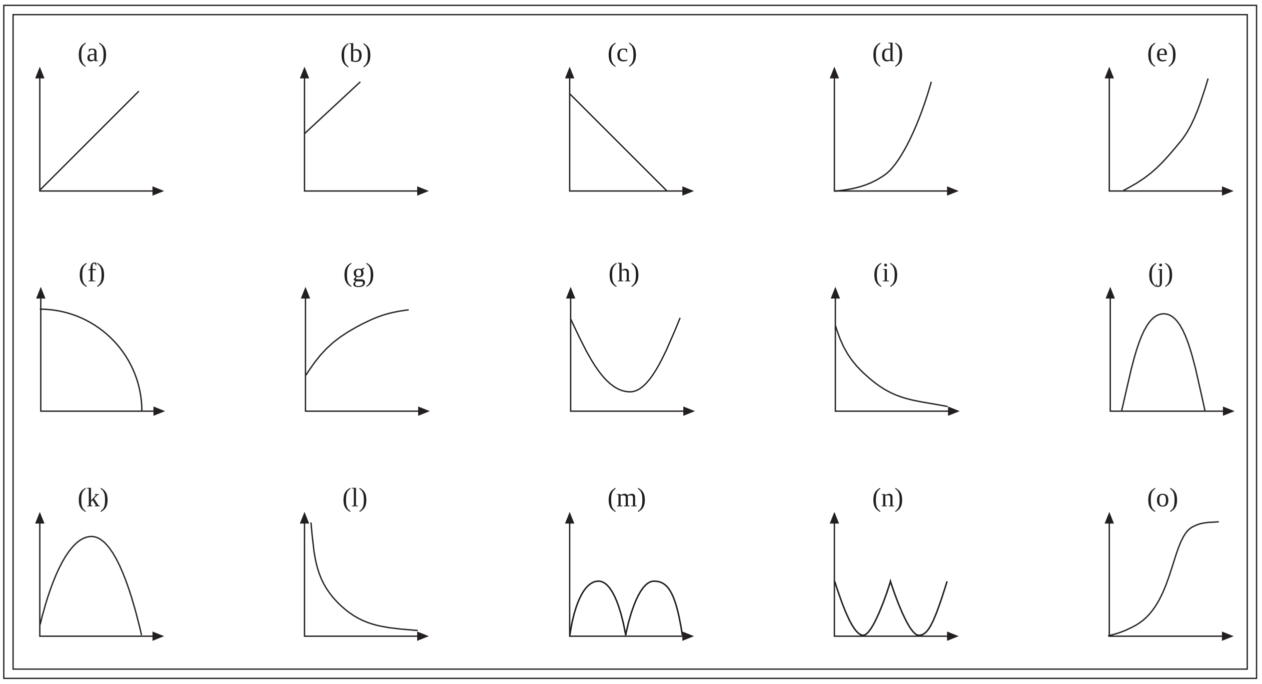
Situation 1 "Prices are now rising more slowly than at any time during the last five years."

Situation 2 "I quite enjoy cold milk or hot milk, but I loathe lukewarm milk!"

Situation 3 "The smaller the boxes are, the more boxes we can load into the van."

Situation 4 "After the concert there was a stunned silence. Then one person in the audience began to clap. Gradually, those around her joined in and soon everyone was applauding and cheering."

Situation 5 "If cinema admission charges are too low, then the owners will lose money. On the other hand, if they are too high then few people will attend and again they will lose. A cinema must therefore charge a moderate price in order to stay profitable."



In the following situations, *you* have to decide what happens. Explain them carefully in words, and choose the most appropriate graph, as before.

How does . . .

Situation 6 the cost of a bag of potatoes depend on its weight?

Situation 7 the volume of a sphere vary with the diameter of the sphere?

Situation 8 the time for running a race depend upon the length of the race?