SSERC
SCOTTISH SCHOOLS EQUIPMENT RESEARCH CENTRE

Science & Technology Equipment News

Number 6 Summer 1995

For teachers in Primary schools and of S1/S2 Science & Technology courses

In this issue we present another selection of suggested practical activities which illustrate aspects of the National Guidelines for Environmental Studies at 5-14. Rather than labour the point, we leave it to readers to match up, for themselves, these practical suggestions to the relevant parts of the Guidelines document. Some schools may find that such an exercise, in itself, provides opportunities for staff development. (A note for the obsessively, politically correct : In all of the following contexts "man" is taken to mean "humankind").

From the earliest periods man has used some form of time measurement, be it only the seasons of the year or phases of the moon. This was all that was needed in simple nomadic or agricultural communities and precise enough for their daily needs. As people began to congregate in villages, and forms of religious ceremonies began, more refined methods of time measurement were needed. Civilisation in early times was concentrated around the Mediterranean, where there was lots of sunshine and water aplenty for the then relatively small populations. Here time keeping was developed along two main lines - from the shadow stick, probably the earlier, and then the water clock. Although crude by modern day standards, sundials and water clocks were eventually developed to give surprising accuracy.

Me and my shadow

Figure 1 shows the sundial in its simplest form - the shadow stick. For pupils, this raises many questions on the apparent movement of the Sun and thus the rotation of the Earth. Time was judged from the position and length of the shadow. A deluxe model would have a pebble to place at the shadow's end. This was, and is, a method used by many nomadic peoples. But ever more inventive and more accurate means of using the Sun to track time were soon devised.

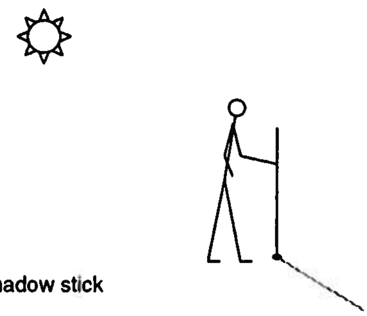


Figure 1 Shadow stick

Some of these, like the Egyptian T-stick (Figures 2 and 3), were portable. But probably the most accurate, early, devices were those designed and used by the Chaldeans. The Chaldeans, the tribe of Moses, are the first people attributed with dividing the day, and the night, into twelve hours each. Their sun-clocks took the form of a hole chipped out of a large rock, with the hour lines converging at the base of the stick or peg. Making your own T-stick is easy. All you need is two house bricks (no jokes please!) a stick about a metre long and a strip of paper (Figure 3).

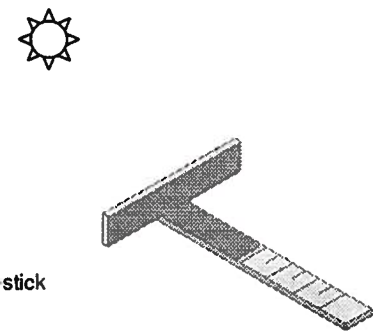


Figure 2 Egyptian T-stick

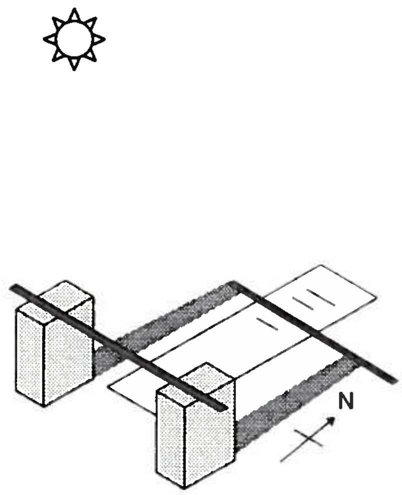


Figure 3 DIY T-stick. The stick should lie East to West and the paper North to South. To calibrate, every half hour mark the top of the stick's shadow on the paper.

Figures 4 below and 5 (overleaf) each show simple ways of making other sun-clocks. In about the same era the Chinese were dividing the day into 100 units. Well into the 19th century the peoples of the East divided the day differently from those of the West.

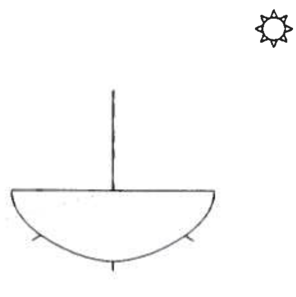


Figure 4 A stick in the ground with marks drawn in the soil to record the passing of time.

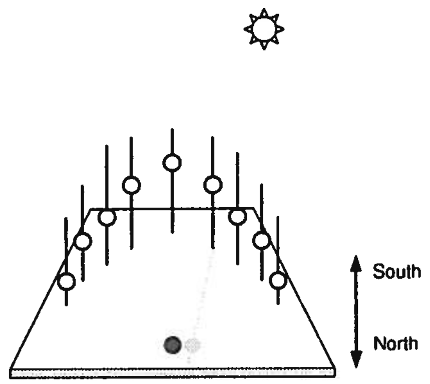


Figure 5 A simple yet more sophisticated design for a sun clock using plastic knitting needles and polystyrene balls. Witha little experimenting it should be possible for the shadow of the ball to fall on the central mark. Read it like a clock, 12 noon is in the central position.

That sinking feeling

Probably one of the earliest methods of giving a repeatable measurement of time was a 'sinking bowl ' (Figure 6). This manner of timing, a crude water clock, is still in use but nowadays mainly for goods 'on hire'. In rural communities in developing countries the goods on hire may be an iron for pressing clothing, hand tools or even farm implements.

Figure 6

The method uses a large basin, or bowl, filled with water. A smaller bowl with a hole in the bottom is placed on the surface of the water in the basin. The water gradually fills the smaller bowl and *time's up* when it sinks.

Water Clocks and Clepsydra

As material standards of living in civilizations grew, so the purely functional became more and more ornate. From simply telling the passage of unspecified periods of the day or night, the peoples of the Middle East moved on to divide the day into more or less the same periods we use today and clock designs become ever more sophisticated (Figure 7 top of next column). For example, the Ancient Greeks introduced alarm clocks using water, novelty clocks, with whistling mechanical birds, and even an early form of the public town clock.

A messy but enjoyable class activity is the making of DIY water clocks. Although the sinking bowl is a simple method, the challenge would be to time an event over an agreed period of time. For example, two or three minutes is a good period to choose if you are using the components shown in Figure 8. Does the shape of the sinking bowl make a difference? Does the position or the diameter of the hole make a difference? No doubt the children will offer other ideas.

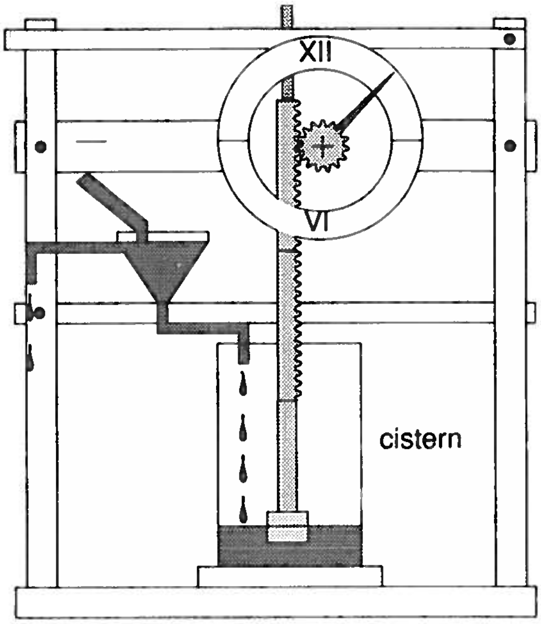


Figure 7 A water clock with a mechanical display - also known as a Clepsydra. The purpose of the funnel-shaped reservoir is to ensure that the rate of dripping into the cistern remains constant.

More sophisticated styles are shown in Figure 9 opposite. We use pill boxes scrounged from our local pharmacies. This is a good source of useful containers, but be quick - these boxes are soon to be replaced by other packaging. There are probably many other designs for simple water clocks and perhaps a brainstorming session is the best stimulus to further work?

Water clocks also lend themselves to extension into other areas of science, technology and maths. The more obvious of these are floating and sinking, estimating, producing a scale and how about water pressure and energy? The water clocks in the drawing show the water dripping out. In reality it will be forced out in a jet to begin with and slowly diminish to a drip. Water pressure from the model clock could then lead on to a study of simple hydraulics and pneumatics.

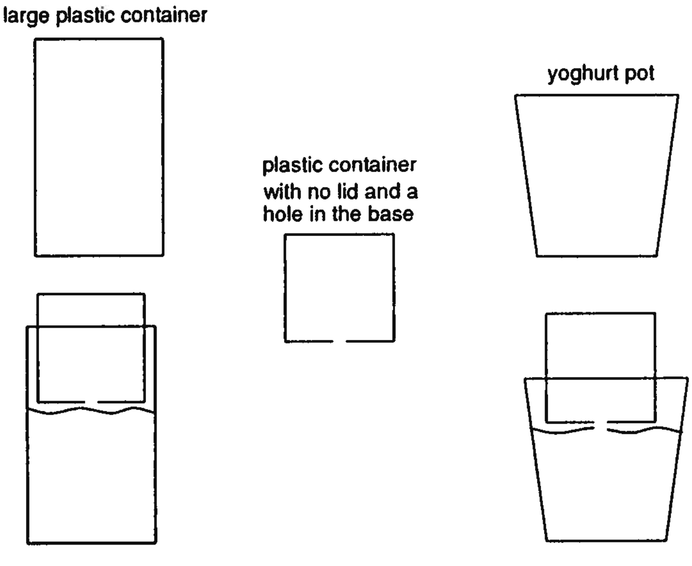


Figure 8 DIY water clocks. Fill the yoghurt pot or plastic container 2/3 full with water. Make as small a hole as possible in the base of the small container then place on the surface of the water. Time is up when it sinks. A small weight may need to be added, depending on the size of the hole, to overcome surface tension.

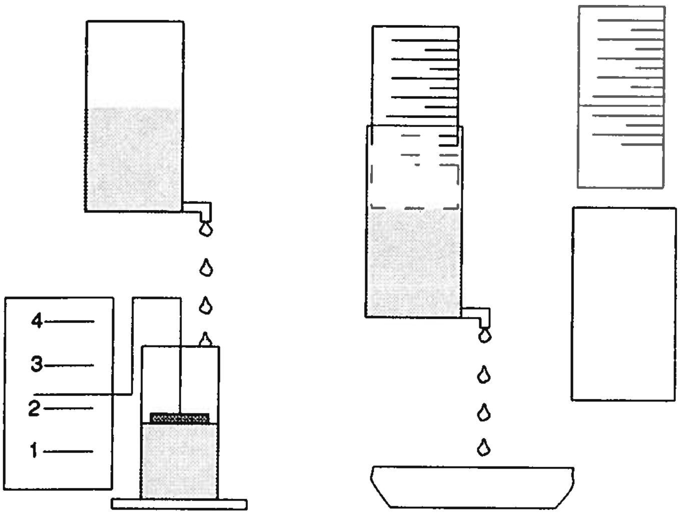


Figure 9 Two methods of using pairs of plastic pill boxes or similar containers to make water clocks. Experimentation is needed with hole sizes.

DIY sundial

Figure 9 shows how we can make our own sundial. It should be a fairly straightforward exercise. The angle of the gnomon (*gnomon* is a Greek word meaning indicator) in our model, will serve for most places in Britain and give a reasonable approximation of the time. Remember to ask the children why the sun-clock and any of their watches are one hour different in the Summer. (And only then make the adjustment for British Summer Time). You may also wish to make an approximate adjustment for longitude. Perhaps the class could make up a table of time conversions for the various cities of Scotland?

SSERC can supply full size paper masters of the sundial design together with a sheet of instructions. We also have a design for a device for telling time by the stars (a nocturnal). If you wish to have a copy of these, please send an A4 self addressed and stamped envelope to :

SSERC, 24 Bernard Terrace,
Edinburgh EH8 9NX

Time is but a passing shadow

Despite early fascination with time-keeping by water or candle, undoubtedly the most accurate early time tellers were sundials. Time was measured from noon one day to noon the next, that is for one revolution of the Earth on its axis. Many medieval churches had sundials long before the more usual steeple clocks. A few old churches have simple marks gouged in the stone of the walls with a hole where a peg would be inserted to cast its shadow to indicate the various times of worship. These are known as scratch dials.

But sundials measure only LOCAL apparent time. A clock in Edinburgh shows exactly the same time as a clock in Glasgow. But sundials in those same cities will always show a different time. A sun-clock in Edinburgh will appear to be running ahead of Glasgow time. Why is this? If the Earth completes one revolution in 24 hrs then 1 hr. will equal $360/24 = 15°$. The Greenwich meridian is taken as 0° of longitude, a large imaginary line drawn around the Earth and passing through both the north and south pole. So every degree we travel west of this line we have to add about 4 minutes and for every degree we travel east of the line we have to subtract 4 minutes.

Early mechanical clocks were bad timekeepers and were often adjusted by the local sundial. As the timekeeping of these clocks improved so the shortcomings of some of the cruder local sundials became apparent, However country people, ever suspicious of townsfolk, took a long time to accept the more accurate and universal time measurement. A clockmaker from a village near Chester was the butt of the village in asserting that his clocks were *right* and the Sun was *wrong*. A memorial to him reads;

"Here's the cottage of Peter, that cunning old fox,

Who kept the Sun right by the time of his clocks."

That's enough of the boring bits!

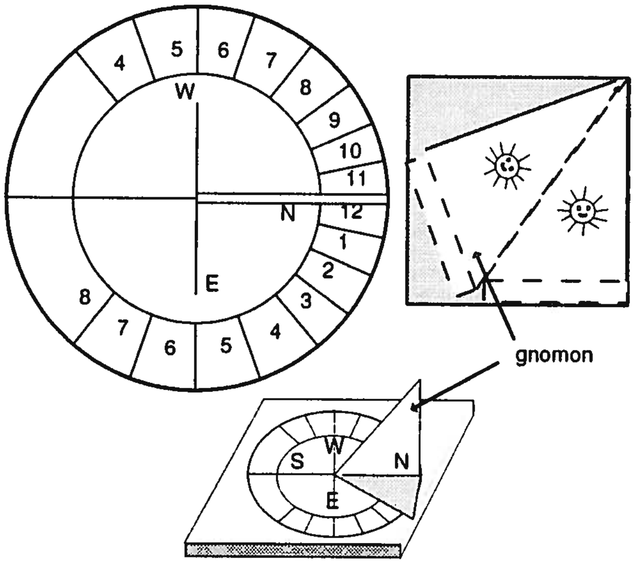


Figure 10 SSERC sundial design. This can be made up from card or wood.

Carpe Diem

The motto *Carpe Diem* was to be found carved on many a sundial and engraved on the faces of mechanical clocks well into the 19th century. Roughly translated it means *seize the opportunity*. But, not surprisingly, this was usually rendered by the old clockmakers as : *make good use of the day*.

Endpiece

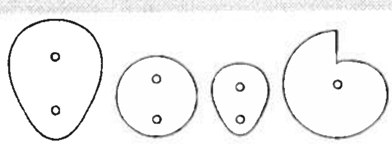
And, finally, a little poem, which in this age of quartz timepieces may well puzzle present day pupils :

There was a man, he had a clock, his name was Mr. Mears,
Every night he wound that clock for five and forty years
And when at last that clock turned out an eight-day clock to be,
A madder man than Mr. Mears, I never hope to see!

Further reading : Sundials & Timedials, Jenkins G. and Bear, M.
ISBN 0 906212 59 6.

Components & Materials List

593	Miniature motor, 1.5V to 3V, 2mm dia. shaft	30p
614	Miniature motor, 3V to 6V, 2mm dia. shaft. Both of the above motors can be used for project work but they run at fairly high speeds, some form of gearing will be required. See item 625	45p
621	Miniature motor, 1.5V to 3V, 1.5mm shaft. The open body of this motor makes it ideal for showing how such a motor is constructed.	25p
811	Worm and gear, gives a 34 to 1 speed reduction.	35p
629	Dual tone buzzer with flashing light supplied with PP3 battery clip. Ideal for model burglar alarms, warning barriers, police car etc..	55p
710	Sonic switch. Clap your hands, the motor starts, clap again the motor reverses, on the third clap the motor stops. Needs 4 AA cells, not included.	50p
645	Ceramic magnets, reasonably strong, various shapes.	7p
688	Crocodile clips, red, miniature, insulated.	5p
759	as above but black.	5p
789	MES (miniature Edison screw) lamps (bulbs) 3.5V.	9p
691	MES battenholders for above.	20p
508	LED (light emitting diode) 3 mm, red.	60p/10
761	LED 3 mm, yellow.	60p/10
762	LED 3 mm green	60p/10
790	3V buzzer.	55p
788	Crocodile leads, assorted colours, insulated croc. clips at ends, 36cm long.	£1.35
791	Propeller, 3 blade to fit 2mm shaft. Blade 55 mm long.	45p
792	Propeller kit with hub and blades for ten 3 or 2 bladed propellers.	£3.50
793	Cotton reels (for making buggies, rubber powered tanks etc.) pack 10.	45p
794	As above but pack of 100.	£3.50
795	Tyre material for cotton reel wheels, per 1 metre length.	90p
796	Pack of 20 pulleys, 5 of each of 10, 20, 30 and 40 mm diameters.	£2.50
797	Pack of 100 pulleys, 10 mm diameter with 2 mm hole for motor shaft.	£10.00
798	Pack of 24 gears, 6 each of 12, 20, 30 or 40 teeth, dia. 15, 22, 32, 40 mm 12 tooth gear fits motor shaft and 40 tooth gear is push fit in cotton reel	£2.00
799	Pack of 24 cams, 6 of each of 4 shapes	£1.00



800	Pack of 100 wheels, 39 mm diameter, assorted colours, 3 mm axle hole	£5.25

Note that sundial or nocturnal templates can be obtained by sending a self-addressed, A4 envelope with a 25p stamp.

Payment with orders less than £5 and please add £1 for carriage then add VAT to the total.

SSERC, 24 Bernard Terrace, Edinburgh EH8 9NX Tel. 0131 668 4421, Fax. 0131 667 9344.