SSERC
SCOTTISH SCHOOLS EQUIPMENT RESEARCH CENTRE

Science & Technology Equipment News

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

In the last issue we looked at a number of simple practical activities which illustrate aspects of Understanding Earth and Space and associated concepts to do with measuring time. We hinted at ways in which the science and technology activities might be linked also, in Topics or by other means, to aspects of Environmental Studies such as People in the Past or People and Place. Early feedback suggests that we are getting close to providing something useful to classroom practitioners. So, in this edition of the News we develop some of the themes from Issue Number 6.

Fair, drawin' in?

By the time this newsletter reaches schools, readers may well be thinking about looking at stars other than our own Sun. Let's be optimistic and forecast an Indian Summer. Then you can instead first extend some of the work we began with shadow sticks and sundials before looking further outward on those clear, sharp and lengthening nights of Autumn.

The sundial we described in Issue 6 provides a good lead-in for children to consider the underlying causes of the seasons. A good question to start things off is : "Would our Scottish sundials also tell the correct time in France, Spain or Australia?" We discussed the effects of longitude last time. You will recall that for every degree we travel east or west of the Greenwich meridian we would need to add or subtract four minutes to or from our sundial's solar time. But what about going north or south along the same line of longitude? What changes might we have to make to the sundial?

Roamin' and the gnomon

Although its effect is less than that of shifting longitude, we do need to adjust our sundial if we wish to use it to tell the time somewhere significantly north or south of the Central belt of Scotland. The angle of the indicator or gnomon on the SSERC sundial is 56° (Figure 1) this matches up with the latitude of the Forth-Clyde valley (Figure 2). This is a good enough approximation for much of the Scottish mainland, but Orkney or Zetland specials could be made available on request.

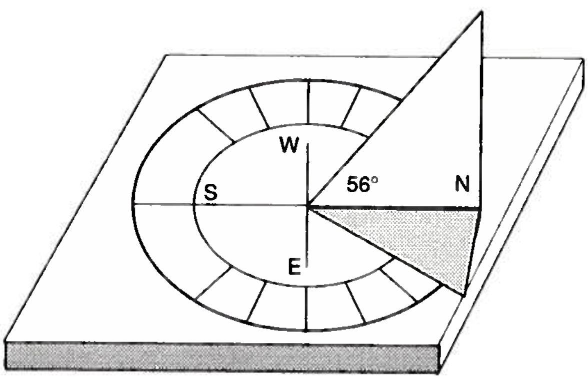


Figure 1 Scottish sundial for Central belt with the gnomon angle roughly matching that of latitude.

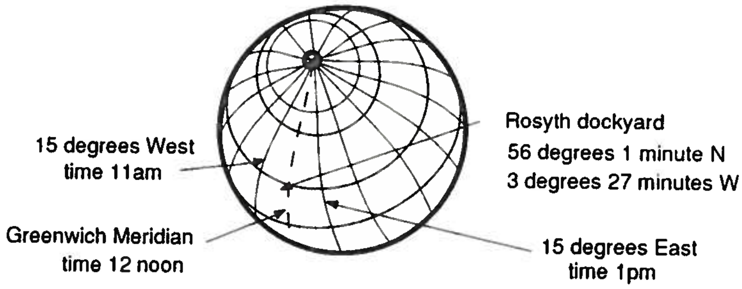


Figure 2 Diagram of Earth : the position of Rosyth Naval Dockyard. The effect of longitude on time relative to Greenwich Mean Time (GMT).

The latitude of any place is the angle which the Earth's surface at that site makes with the Equatorial plane (see Figure 3). So the angle that our gnomon makes with the base of the dial needs to be the same as the angle of latitude for the location at which we intend to tell the time.

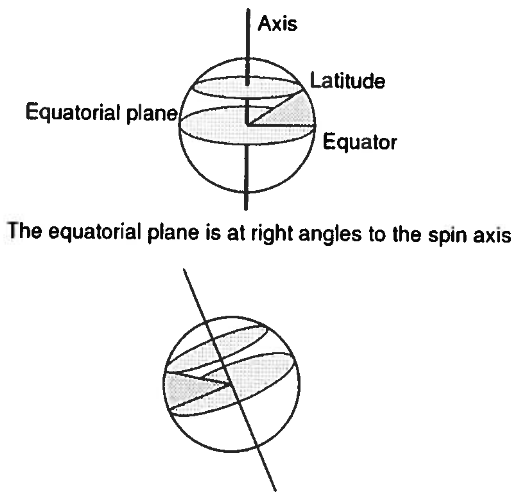


Figure 3 Latitude as the angle the surface of that part of the Earth makes with the Equatorial plane.

It's worth digressing here for a bit of simple maths and a mapping exercise, to develop this idea of defining the position of a place by the intersection of imaginary lines. We got the angle for our Edinburgh sundial from a set of Admiralty tables which cites Rosyth dockyard (see Figure 2), whilst it remains there, as being at 56° 01'N (its latitude) and 3° 27' W (its longitude). Anticipate possible mix-ups over "minutes" as units of time and as sixtieth parts of one degree of an angle. Best not labour this non-metric point! A good practical exercise is a plan of the school based on a pupil-devised grid reference system. How about a grid location for the classroom or even for each group's table?

To every season: turn, turn

Note the angle of tilt of the Earth, of 23.5° or so, in the lower part of Figure 3. Angles relative to the equatorial plane haven't changed and thus neither has the latitude shown. But it is this angle of tilt of the Earth's axis relative to the plane of its orbit round the Sun which is the key to variation in daylength over the year and of the nature of the seasons themselves.

This idea is illustrated in Figure 4 at the foot of this page. It may be demonstrated in the classroom using a simple orrery (a solar system model). It can even be shown in a darkened room using little more than a model globe and a powerful torch. It is however important then to preserve that all important angle of tilt as the globe circles your artificial Sun.

Teacher centred system

That last suggested activity emphasises the need for a consistently heliocentric (Sun-centred) view of our own system. This may be reinforced by demonstrations with model planetaria - such as the Helios model available from a number of educational suppliers and held in some Teachers' Centre loan collections. The major snag with such models is their inaccurate scaling, something which with very little prompting the children will themselves suggest. In order to fit the solar system into a model of manageable size the relative sizes of planets and Sun, as well as the distances between them, have to be distorted.

An instructive exercise is to supply the pupils with sets of about seven differently sized circles drawn on A4 paper or card. One of the set should represent the Sun another the Earth, both drawn to the same scale. On A4 a convenient diameter for the Sun is about 140 mm at which scale the Earth is just about 1 mm across. Ask the children to say which of the whole set they think is the Earth and which the Sun. At a later stage you could begin to point out the vast distances in the Universe. For example, suppose we represent the Sun as a 2 m diameter tractor tyre in the centre of Scotland. Ask the pupils where we would have to site a scaled version of the next nearest Sun (star)? Jerusalem would be about right.

Other realistically scaled models can be simply made. We had great fun with one of these recently. This was at a Primary Science and Technology Week down in the Borders. You need a teacher or an adult to be the Sun and make groups of pupils into planets. The other necessary ingredient is a biggish field or a large playground.

We originally worked with relative distances and sizes calculated on a 1 metre to 100,000,000 km scale (Table 1). The children came up with the idea of substituting human steps or paces as a means of estimating distances from our Sun God teacher in the middle of Melrose Rugby Club's practice pitches. They also spotted that - "to keep it fair" - the same person, or persons with similar sized steps, should do the pacing out. Each pupil group had their own label on a cane (later to double as their shadow stick clock) declaring them collectively to be Mars, Earth, Jupiter or whatever. As Saturn disappeared across the road and onto the hallowed Greenyards, Pluto seemed about to escape into the magical Eildon Hills. We began to think about adjusting our scaling - by about half we thought! This we did with the afternoon class, but even so Pluto had still to cross the road (under teacher supervision with Green Cross Code practice as an inter-planetary travel bonus). Neptune returned, collectively complaining of the cold when they had been "so far from the Sun". Sometimes, I really do like the weans.

For some real fun try to get the planetary groups to orbit the 'Sun' at fixed distances. Witness the collapse of a solar system!

The final column of Table 1 points to another possible model with planetary sizes also scaled and not just their separations. You could lose a fair bit of tapioca this way.

Planet	Sun to planet distance (m)	Planet diameter (mm)	Model
Sun		140	grapefruit
Mercury	5.8	0.5	poppy seed
Venus	10.8	1.3	tapioca
Earth	15	1.3	tapioca
Mars	22.8	0.7	poppy seed
Jupiter	77.8	14	hazelnut
Saturn	142.7	12	hazelnut
Uranus	287	5	peppercorn
Neptune	450	5	peppercorn
Pluto	590	0.6	poppy seed

Table 1 Relative interorbital distances in metres and diameters in millimetres of the Sun and planets.

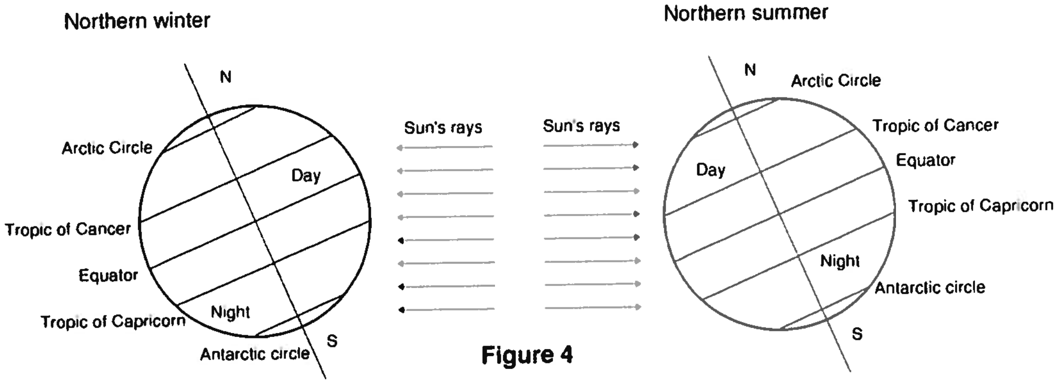


Figure 4

Even farther out

We have estimated our position on the Earth. We have told the time by the Sun. Can we do much the same at night? Late Autumn usually brings a time of clear, crisp nights with stars to be seen in abundance (except in towns and cities where light pollution from sodium street lamps is now a serious nuisance). Actually observing the stars has to be mainly an activity for outside school hours. But we can do a lot to encourage children to observe, to see and not just look. We can also prepare them to make the most of what they might see. As before, we can start with a good question such as "What is a star?". The Sun, sitting at the centre of our own solar system is a star (a Red Dwarf). Most other stars in the universe are also suns of some sort or other. Next question: Can we use stars to know roughly where we are or which way to go? Can they, like our own star the Sun, help us tell the time?

Because of the Earth's rotation all stars apparently rise in the East and sink in the West. They can also tell us which way is North. In favourable conditions we can even use a night-time equivalent of the sundial, a *nocturnal* to tell the time. Figure 5 shows a small set of three groups of stars (constellations). To the right is probably the most easily recognised of all - *The Plough*, *Ursa Major* or *Great Bear*.

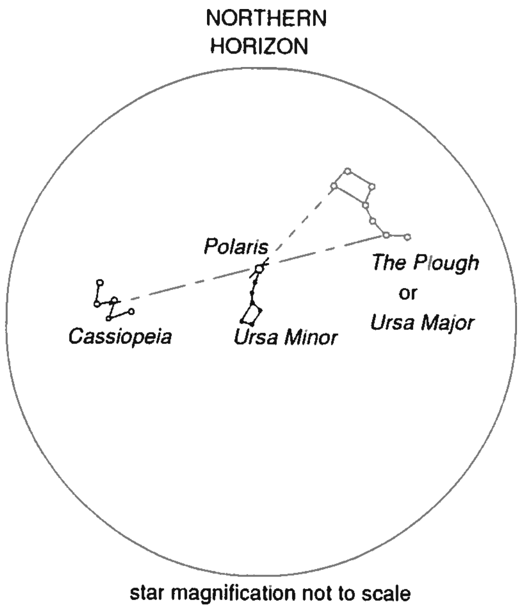


Figure 5 Sector of northern hemisphere night sky showing the location of the pointers, Mizar and the Pole Star.

The two bright stars on the front of the 'ploughshare' are known as *Dubhe* and *Merak* - 'the pointers', This is because if an imaginary line is drawn through these two stars, the first bright star that line will meet is *Polaris* - the *Pole Star*. If we were to travel toward that star we would be heading north.

Two other weel kent constellations in this area of the sky are *Ursa Minor* and *Cassiopeia*. *Ursa Minor* as the name suggests looks like a smaller version of the *Great Bear* or *Plough*. The *Pole Star* is at the start of the little version's handle. *Cassiopeia* can be found by drawing another imaginary line from the second star in the handle of the *Plough* through the *Pole Star*. About the same distance from one side of *Polaris* as *Ursa Major* is from the other, there's a constellation which looks like a giant *W*.

This *W* shape is *Cassiopeia*.

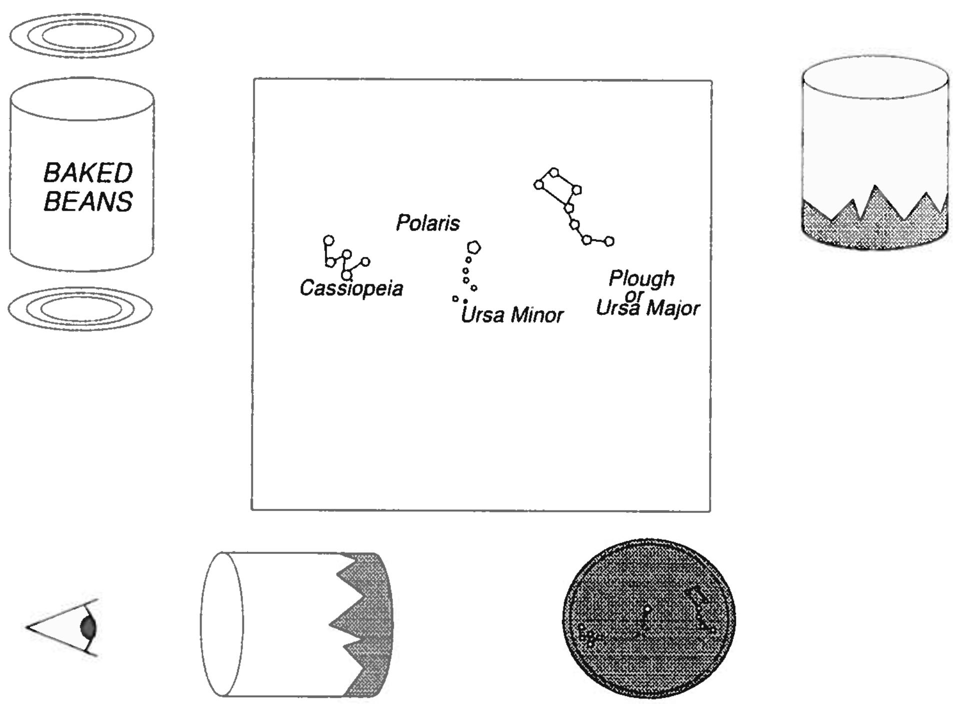


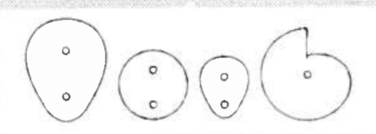
Figure 6 Tin can constellations. (Adapted, many years ago, from an idea which we think first appeared in the School Science Review [Association for Science Education]).

The second star in the handle of the *Plough*, which we use as our marker for *Cassiopeia*, is really two stars - a double star called *Mizar*. It has another, smaller, bright star alongside - *Alcor* or *The Cavalier*. This too is a double star, but it can be seen as such only by those with very good eyesight. And so, it was known to the Arabs as *Saidak* : 'The Test'. As with the Chaldeans and their sunclocks : Whilst our ancestors were still daubing their bodies with blue dye - Callanish and the Ring of Brodgar notwithstanding - the peoples of the Middle East were also mapping and naming the heavens. Figure 6 shows one active way of introducing pupils to these patterns in the night skies. We call these models "tin can constellations". What is needed is an empty tin can with both ends removed. Make sure you use a modern tin-opener leaving no sharp or ragged edges. Next, take a piece of dark paper, sufficient to cover one end of the can and a sharp pencil. Mark a few constellations on the paper. Pierce each star position with the sharp point of the pencil. Tape the paper to one end of the can and look through the other, Remember to have the correct side of the paper facing inwards. You now have an indoor telescope, a miniature planetarium!

Astronomers tell us that the whole of the night sky in our hemisphere appears to slowly move around *Polaris*. How could we test this statement? Our tin can constellations may help. The pupils could take a can home and note the position of *Ursa Major* at say six o'clock in the evening, then check again at eight o'clock. As an extension they could find out if the position of the constellation was the same on Monday night at six o'clock as on Friday night at the same time. Constellations do apparently move around the heavens. We can use this to make a time keeping device - a Nocturnal (see over for an offer of plans).

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

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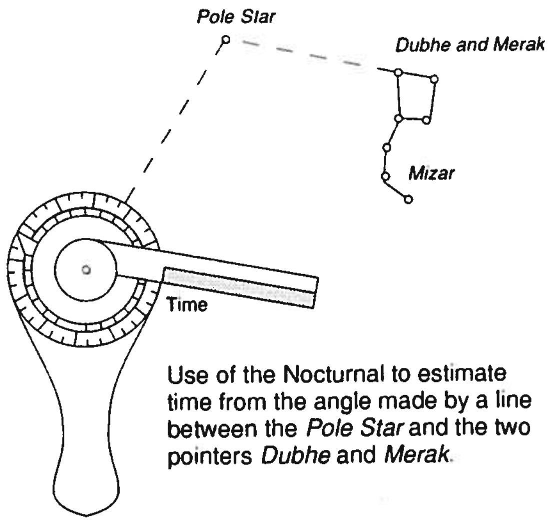

Use of the Nocturnal to estimate time from the angle made by a line between the *Pole Star* and the two pointers *Dubhe* and *Merak*.

Nocturnal - working model

The apparent regular movement of the constellations around the Pole Star enables an observer to tell the time (known as sidereal time) with a device called a nocturnal.

Send a stamped, self-addressed A4 envelope for a free template and a set of instructions to make your own nocturnal.

We also have a handy A4 master of a collection of suitable circles for the Sun and Earth exercise described on page 2 and our offer of sundial plans (Issue 6) remains open.