# THE SUNDIAL AT GLAMIS CASTLE

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You *may* have heard of Glamis Castle. It is a tourist attraction open to the public for most of the year. The seat of the Earls of Strathmore and Kinghorne, it was the childhood home of Her Late Majesty Queen Elizabeth the Queen Mother, and the birthplace of the late Princess Margaret. Shakespeare mentions "Thane of Glamis" in his play, Macbeth, and the castle is pictured on the £10 notes issued by the Royal Bank of Scotland

You may *not* have heard that the Castle has a magnificent sundial! (See Fig. 1 and the front cover.) The literature[1-5] gives architectural descriptions, but it may be worth expanding in order to detail some of the more mathematical features.

*Fig. 1. The sundial at Glamis Castle (SRN 1489).*

It was fashionable in Scotland between about 1620 and 1730 to erect obelisk dials with other types of dial incorporated within the pillar.[4] The Glamis sundial is a particularly fine example of this, ingeniously including the Earl's coat-of-arms and coronet with 84 time-recording faces. It is one of the largest sundials in Scotland. The art of the designer, the skill of the stonemason, the genius of the mathematician and the pride of the earldom are all exuberantly displayed in this extraordinary celebration of geometrical shape and aristocratic confidence. The carving, sometimes described as 'baroque', is superbly and delicately executed. The dial may be tentatively dated to about 1683 because the Third Earl of Kinghorne (1643-1695) confided to his diary[6] the tantalisingly brief statement, "*There is in the garden a fine dial erected*" sometime between the years 1678 and 1684. However, Slade[5] dates it to before 1660.

The dial to a certain extent looks as if it might consist of *two* dials, each originally intended to be ground mounted, with one placed on top of the other. However, that hypothesis is not mooted in any literature we have seen, so we shall continue to assume that it was always intended to be as it now is, and so may be described in three parts: the obelisk, the lion dial and the pineapple.

### The Obelisk

The whole structure stands 21 feet (6.5 m) high. It is mounted on an octagonal plinth situated in the lawn to the south of the castle and to the east of the main drive at a latitude of approximately 56½° North and a longitude of approximately 3° West.

The top consists of an eleven-point coronet standing on a fleur-de-lys supported by what could possibly be described as four modified logarithmic spirals. One corner of the plinth points due north (see Fig. 2). Local apparent noon may be determined when the shadow of the whole obelisk falls in the direction of that north-facing plinth corner.

*Fig. 2. One corner of the octagonal sundial plinth points north. When the shadow of the obelisk falls on this corner it is local apparent noon. This photograph was taken in the early afternoon when the shadow had moved past the noon point.*

### The Lion Dial

The lion dial consists of four vertical dial faces carved in stone – one for each cardinal point of the compass (Figs. 3 (a-d)). Each of these faces is supported by a carved lion sitting on a tree stump. They are reminiscent of the lion rampant in the earl's coat-of-arms and also in the royal


*Fig. 3. The lion dials: (a) north, (b) south, (c) east (d) west.*

standard of Scotland (Fig 4). The south face (meridional) is elliptical in shape measuring 19 inches by 14 inches (48 cm by 35.5 cm), the east face (oriental) is 13½ inches (34 cm) square, the west face (occidental) is rectangular measuring 15½ inches by 13½ inches (39.5 cm by 34 cm) and the north face (septentrional) is circular measuring 16 inches (40.5 cm) in diameter.

The hours marked are:

| | |
|---|---|
| South face | 6am – 6pm |
| North face | 4am – 6am and 6pm – 8pm |
| East face | 6am – 11am |
| West face | 1pm – 6pm |

The hours are numbered using Roman numerals.

Above the lions is a stone canopy supported by an octagonal central pillar and four beautifully carved helical columns. This arrangement means that the lions are adjustable. They may be rotated on a vertical axis to ensure that the gnomons on each face lie exactly in the meridian, thus eliminating any errors introduced in construction.

The sundial lions are similar, but not identical, to the wooden lions in the castle dining room (Fig. 5). Slade[5] attributes the carving of the dining room lions to Jan van Santvoort, which would date them to about 1683. It seems possible that the dining room lions were used as a pattern for the sundial lions, or vice versa.

*Fig. 4 (left). The lion rampant in the royal coat-of-arms and the arms of the Earl of Strathmore and Kinghorne.*

*Fig. 5 (right). One of the lions in the Drawing Room at Glamis Castle, attributed to Jan van Santvoort in 1683.*

At latitude 56½º N, the theoretical angle between the noon line and each of the seven o'clock am and five o'clock pm lines on a South face is 64º. The measured angle at Glamis is 64º, showing that the dial was designed for the latitude of 56½º N and so was almost certainly designed specifically to be erected at Glamis. The gnomons sit at an angle of 56½°, further confirming that the dial was designed for its present latitude. (The north face gnomon was replaced in 1985.)

*Fig. 6. The pineapple.*

**The Pineapple (or Stellar Rhombicuboctahedron)**

'Pineapple' is not a geometrical term but it is a colloquial name used at Glamis to refer to the complex figure with many faces situated within the sundial structure.

The pineapple at Glamis Castle (Fig. 6) is based on an Archimedean solid known as a rhombicuboctahedron. Such a figure has 8 triangular faces and 18 square faces. (Fig. 7.) At Glamis, each square face (except the top and bottom ones) has a regular square pyramid surmounted on it, and each triangular face has an irregular triangular pyramid surmounted on it. The square faces measure 16 inches (40.5 cm) square. The angles of the pyramids are set such that four triangular vertical, direct faces are presented to each of north, south, east and west. These triangles are isosceles.

The intermediate compass points of north-east, south-east, south-west and north-west similarly each have four triangular vertical, declining faces. In addition, each of these eight compass points is presented with six other faces which variously recline and procline.

Each of these 80 faces is furnished with a gnomon set at an angle compatible with their being designed for the latitude of Glamis. The faces are scribed with the relevant hour lines for the angles at which they face, marked with Arabic numerals.

The pineapple sits on a short cylindrical pedestal above its square plinth, again making it adjustable so that the whole pineapple may be correctly aligned with the meridian.

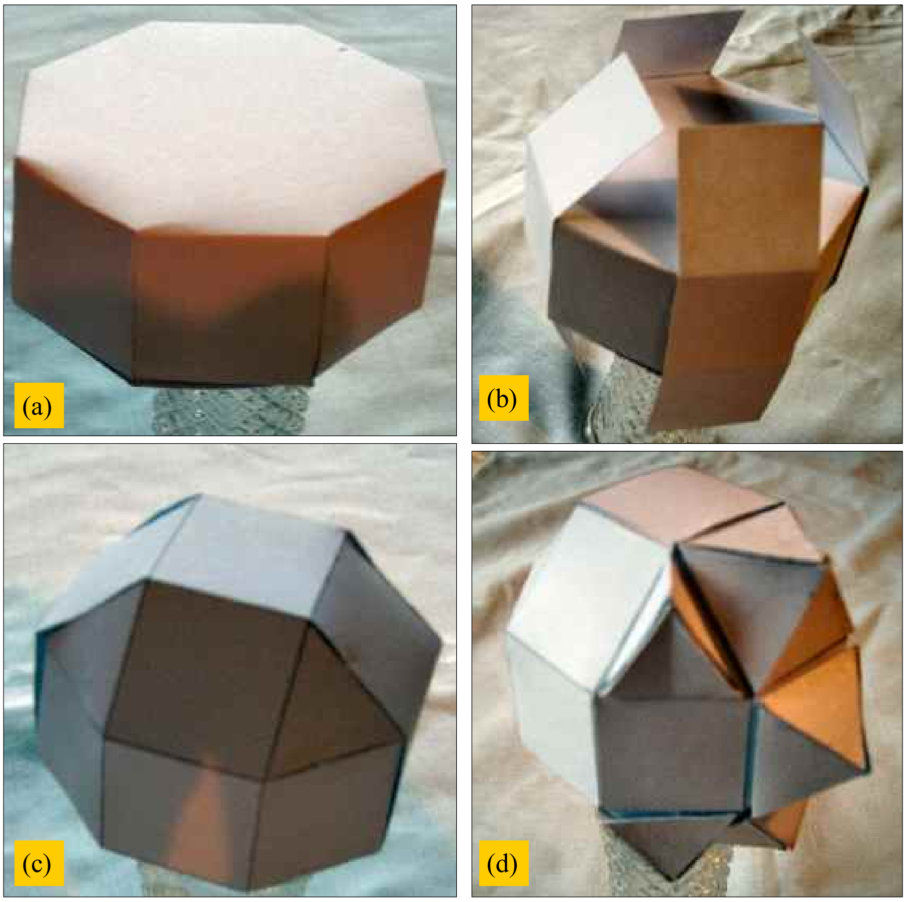


*Fig. 7. To make a pineapple:*

*(a) take an octagonal prism with square faces;*

*(b) paste a piece of paper on four of the faces as shown;*

*(c) fold the paper and fill in the holes to make a solid figure with square and triangular faces. This figure is called a rhombicuboctahedron;*

*(d) place a square pyramid on each square face and a triangular pyramid on each triangular face. It is now a stellar rhombicuboctahedron.*

*Fig. 8. The EoT table engraved on the base of the sundial.*

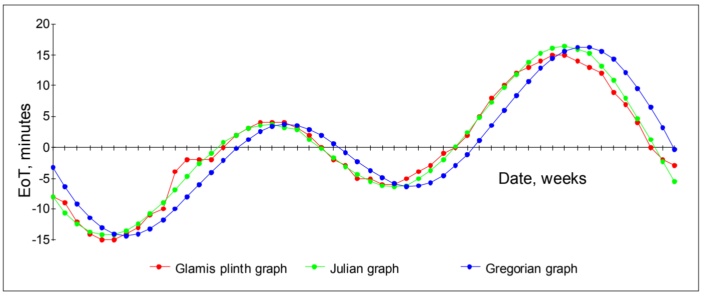


*Fig. 9. Graphs of theoretical EoT for the Julian and Gregorian calendars and for the Glamis values.*

**The Equation of Time**

The Glamis sundial is a contender for having the oldest inscription of the Equation of Time in the British Isles.[7] It is engraved on the plinth of the Glamis sundial (Fig. 8) and has been transcribed in Table 1. The line below the names of the months shows the dates of the first days of each week counting from 1 January. Below each date is the equation of time for that date in minutes. Below that again is an indication of whether the sun is fast or slow of mean time.

In Fig. 9, the graph shows the theoretical equation of time in blue for the present day Gregorian calendar. The green graph shows the equation of time had the eleven days not been removed in 1752. The red line shows the equation of time as engraved on the plinth of the Glamis sundial. The Glamis line closely follows the theoretical line for the Old Style calendar, apparently showing that the equation of time at Glamis was engraved before 1752. The x-axis shows a division for each week of the year from January to December. The y-axis shows the correction factor in minutes.

**Mathematics**

Calculating the hour lines for those 80 declining and reclining faces was quite a tour-de-force for a mathematician at that time.[8] But the mathematics of the practical time recording part of the structure is only part of the expression of mathematical imagery. The following mathematical terms have already been mentioned, but bringing them together emphasises just how much mathematical thought has gone into the construction: line, angle, triangle, square, rectangle, octagon, circle, ellipse, isosceles, face, logarithmic spiral, helix, Roman numeral, Arabic numeral, prism, rhombicuboctahedron, pyramid, cylinder.

It is also of note that the Equation of Time values on the Glamis sundial do not fit precisely with any of the early published tables.[7] This leads to the suspicion that the Glamis table was composed independently, perhaps by an astronomer with a good longcase clock and making comparisons with sidereal time.[7]

Who could the mathematician have been? The finger of possibility points to James Gregory, Professor of Mathematics at the University of St Andrews from 1669 to 1674 (Fig. 10). It must be said that the evidence for Gregory being involved rests entirely on his being a mathematician about the right time, fairly nearby (Glamis is about 20 miles from St Andrews) and his known possession of a

| January | | | | | February | | | | March | | | | April | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 8 | 15 | 22 | 29 | 5 | 12 | 19 | 26 | 5 | 12 | 19 | 26 | 1 | 8 | 15 | 22 | 29 |
| 4 | 7 | 12 | 14 | 15 | 15 | 14 | 13 | 11 | 10 | 4 | 2 | 2 | 2 | 0 | 2 | 3 | 4 |
| | | SUN | | | | SLOW | | | | SLOW | | | | * | | FAST | |

| May | | | | June | | | | July | | | | August | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | 14 | 21 | 28 | 4 | 11 | 18 | 25 | 2 | 9 | 16 | 24 | 1 | 8 | 15 | 22 | 29 |
| 4 | 4 | 3 | 2 | 0 | 2 | 3 | 5 | 5 | 6 | 6 | 5 | 4 | 3 | 1 | 0 | 2 |
| | FAST | | | * | | SUN | | | SLOW | | | | | | * | |

| September | | | | October | | | | | November | | | | December | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 12 | 19 | 26 | 3 | 10 | 17 | 24 | 31 | 7 | 14 | 21 | 28 | 5 | 12 | 19 | 26 |
| 5 | 8 | 10 | 12 | 13 | 14 | 15 | 15 | 14 | 13 | 12 | 9 | 7 | 4 | 0 | 2 | 3 |
| | SUN | | | | | FAST | | | | FAST | | | | * | SLOW | |

*Table 1. Transcription of the Equation of Time table carved around the pedestal of the Glamis dial.*

*Fig. 10. Were they friends? Left, Patrick, Third Earl of Kinghorne (1643–1695); right, Professor James Gregory (1638–1675) (picture courtesy The Marischal Museum, Aberdeen).*

*Fig. 11. This split second clock by Joseph Knibb was commissioned in 1673 by James Gregory. It still has pride of place in the Senate Room at the University of St Andrews.*

clock! Checks with archivists at both St Andrews University and Glamis Castle have revealed nothing to connect the Third Earl with Gregory. Nevertheless, we *do* know that the Earl was familiar with both the town and university of St Andrews. We know, for example, from his own diary[6] that when a teenager, he had been a student at the university himself and that, in later life, he bought his carriage wheels in St Andrews. So the Gregory connection is possible, if not proven. We also know that the Earl had master craftsmen on site carrying out extensive elaborate carving and building work. It is possible that Gregory was given access to the skills of these craftsmen in exchange for providing the Castle with a fine sundial.

**The Bad News**

Unfortunately, we cannot easily use the Glamis sundial to set our watches today. Not one of the lion dials faces exactly in its correct direction and the whole pineapple is about 6° out of alignment. Also, the equation of time carved on the plinth is not correct for our modern calendar. We can, however, continue to admire it!

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