

A Mathematical and Scientific Walk Around St Andrews

The route visits sites associated with mathematics and science around St Andrews. A map showing the location of the sites may be found at the end of the text. The walk was originally produced for the British Society for the History of Mathematics Conference in St Andrews in 2016.

St Andrews is known for its University, its beaches, and golf. In medieval times it was a major centre of pilgrimage. St Andrews is Scotland's first university and the third oldest in the English speaking world, constituted by a papal bull in 1413.

Note: The University of St Andrews had 3 colleges, St Salvator's (founded 1450), St Leonard's (founded 1512), and St Mary's (founded 1538). In 1747 St Salvator's and St Leonard's merged to form United College.

1. The St Andrews to Leuchars railway, opened in 1852, was the first to be built on Thomas Bouch's 'cheap principle', which avoided expensive land purchases, used light locomotives and low design speeds, making branch lines to many small Scottish towns viable. The original stationmaster's house is now the Jigger Inn on the Old Course. It was superseded by a new station in a cutting, now a car park, below the bus station. The viaduct for the continuation to the East Neuk is now a footpath leading to the Botanic Gardens (q.v.).

2. "The Himalayas", is the descriptive local name for The Ladies Putting Green, established in 1867. You don't need to take your golf too seriously here, despite being by the Old Course (q.v.). It can get crowded on sunny weekends – call 01334 475196 to check opening times and queues.

3. Royal and Ancient Clubhouse, built in the 1850s to house the Royal and Ancient Golf Club which, from 1754-2003 was responsible for the international rules of golf. The Clubhouse faces "**The Old Course**", the oldest golf course in the world, and still a public course. You can walk around it on Sundays when there is no play (and citizens of St Andrews may hang their washing out, but seldom do). Here, **Peter Guthrie Tait** (1831-1901) was inspired by his son Freddie's (an amateur champion) long drives to question why a golf ball will travel further than hydrodynamic theory predicted possible, concluding that backspin was the key.

Notes: Freddie won the Amateur Championship twice, in 1896 and again in 1898. He tied for third place in the Open in 1896 and 1897, and was leading amateur in the Open six times. He was killed in action in 1900 during the Boer War.

Peter Guthrie Tait was a close friend of James Clerk Maxwell, Professor of Natural Philosophy at Edinburgh, author with William Thomson (later Lord Kelvin) of the *Treatise on Natural Philosophy* (the bible of late 19th century physicists), promoter of quaternions and a major developer of knot theory (closely connected with vortex atoms). With his family, he started coming to St Andrews to play golf in 1868. They had a house in Gibson Place (so presumably overlooking the Old Course). His investigations of golf balls began around 1887 and were both experimental and mathematical. All that was previously known about the flight of golf balls was the distance gone, the time taken, and an estimate of the height. Tait experimented on the impact of different materials (eg. iron and gutta percha), and on the

momentum of golf balls (by getting Freddie and other champion players into the lab to drive balls hard into a pendulum whose consequent swing was observed from the safety of a half-closed door!). His conclusions about backspin were published in 1896. He had a club constructed for himself with horizontal grooves that would help increase the backspin. The effect of spin on the path of balls is formally known as the Magnus effect, first *investigated* by the German physicist Heinrich Gustav Magnus in 1852. However, in 1672, Isaac Newton had *described* it and correctly inferred the cause after observing tennis players in his Cambridge college. In 1742, Benjamin Robins, a British mathematician, ballistics researcher and military engineer, explained deviations in the trajectories of musket balls in terms of the Magnus effect.

4. Robert Chambers' house. Chambers (1802-1871) was a publisher, co-founder of W&R Chambers, and author of the controversial *Vestiges of the Natural History of Creation* (1844). He lived in St Andrews in the 1840s, returning in the mid 1860s when he built this house.

5. Józef Kozacki invented the portable mine detector in a laboratory in the Ardgowan Hotel on North St. Kozacki (1909-1990) was a signals officer of the First Polish Army, stationed in St Andrews during World War II; he tested prototypes of the detector on the West Sands.

6. St Salvator's College and Chapel were founded by Bishop Kennedy in 1450, and the frontage survives virtually intact with residential buildings to the west of the great tower and the chapel to the east. **John Maoir**, known for his work in philosophy, logic and in particular on infinity was provost 1534-1550. **John Napier**, known for the discovery of logarithms and other calculation methods including '**Napier's Bones**', enrolled as a student in 1563 but there's no evidence of him having graduated (which was not uncommon at the time) (published logarithms in 1614). The "PH" in cobbles in front of the tower, marks the site where Patrick Hamilton, one of St Andrews many martyrs, was burnt in 1528. On the second buttress from the east, just below the level of the statue niche, is a **sundial** scratched in the stone (missing its gnomon). The **Benjamin Franklin plaque**, at the east end of the railings, commemorates the award of an Honorary Degree and Freedom of the Burgh, to Franklin in 1759.

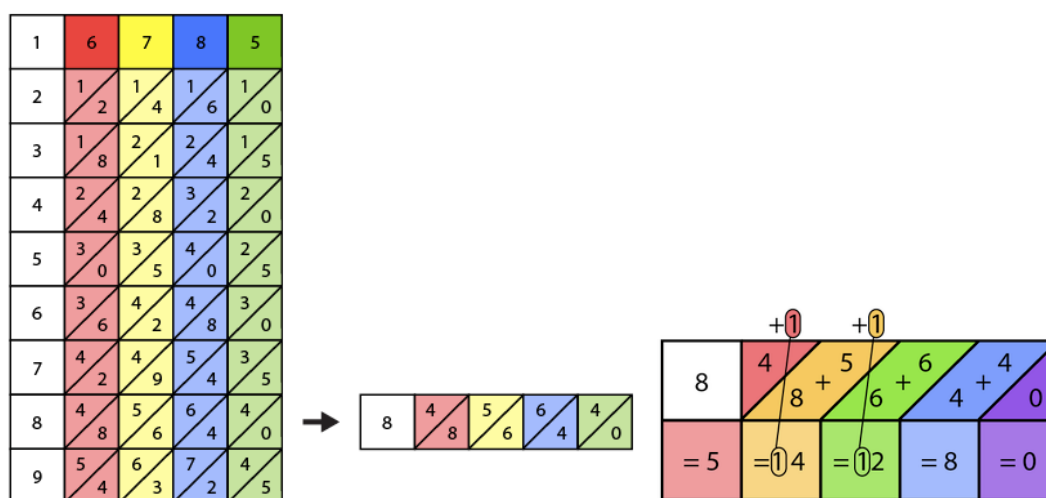
Note: This type of scratch sundial is apparently rare in Scotland, though common in England. It would not have recorded the same time throughout the year, and was used as a marker for church services rather than as a timepiece <http://www.saint-andrews.info/sundials.html>

John Maoir was interested in mathematics and logic and applied these to physics, writing an important text on the infinite *Propositum de infinito* in 1506: ... *in which he argues in favour of the existence of actual infinities and discusses the possibility of motion of an infinite body*. Maior taught for a while at the Sorbonne in Paris. Some of his Spanish pupils there, returned to Spain and became the "calculators" who studied mechanics, being particularly involved with numerical examples, and using as their main tools the elements of proportion theory and infinitesimal arithmetic. <http://www-history.mcs.st-and.ac.uk/Biographies/Maior.html>

Napier: <http://www-history.mcs.st-and.ac.uk/Biographies/Napier.html>



A set of Napier's Bones (Wikipedia)



Multiplying 6785 by 8 (Wikipedia) – Reading the results of the sums from left to right produces a final answer of 54280.

7. **The Martyrs Kirk** was built in 1926-8, but closed in 2008. It now houses the **University Special Collections** including rare mathematical books and archives.
8. **MUSA**, displays many of the University's treasures, including the Cole Astrolabe commissioned by James Gregory (q.v.) in 1675. Currently closed for extension.
9. **Castle**. Founded around 1200, rebuilt in the late 14th century and extensively repaired after the siege of 1546-47. Known for its bottle dungeon (John Knox was the best known inmate), and mine and counter-mine. Castle and visitor centre open daily 09.30-17.30.
10. **Harbour barometer** in the wall of 35 North St, with both an aneroid and a Fitzroy barometer with storm glass (but missing its thermometer). Following violent storms in 1859, Admiral Fitzroy instigated the distribution of barometers to many fishing ports enabling weather prediction before fleets set out.

Note: The wording on the barometer scales was suggested by Fitzroy. Admiral FitzRoy (1805-1865) was a navy surveyor, a one-time Governor of New Zealand, and inventor of the "weather forecast". In 1854 he established what would later be called the Met Office, and created systems to get weather information to sailors and fishermen for their safety. He was a friend of Francis Beaufort (of the Beaufort scale), and Charles Darwin's commanding officer on HMS Beagle.

A storm glass contained liquid whose appearance predicted storms (Fitzroy claimed). The liquid within the glass is a mixture of several ingredients, most commonly distilled water, ethanol, potassium nitrate, ammonium chloride and camphor, a mixture Fitzroy had used on the Beagle. https://en.wikipedia.org/wiki/Storm_glass ; https://en.wikipedia.org/wiki/Robert_FitzRoy ;

11. Preservation Trust Museum, open daily 14.00-17.00

12. Cathedral. Once Scotland's largest church, the Cathedral was founded in 1160 alongside the existing Augustine Priory with its church of St Regulus and St Rule (c.1080) which housed the relics of St Andrew. Climb St Rule's Tower for a magnificent view. Open daily 09.30-17.30.

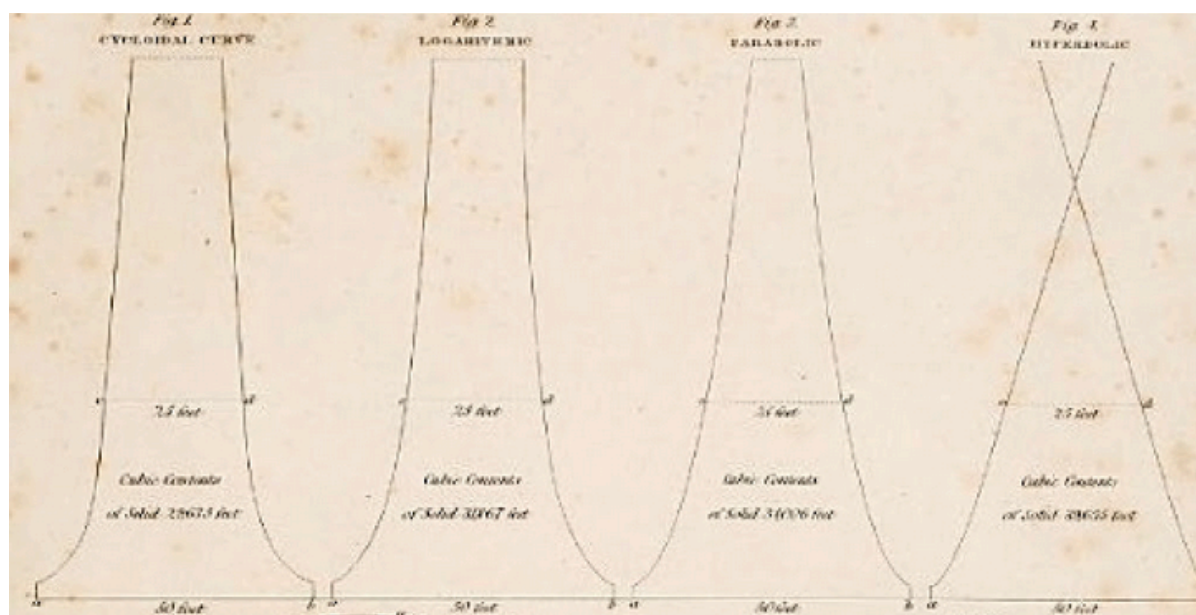
Note: https://en.wikipedia.org/wiki/Saint_Regulus

13. Bell Rock Lighthouse. Built by Robert Stevenson in 1807-10 and one of the world's greatest engineering feats at the time, the lighthouse is visible as a white speck (or light) on the horizon on a clear day. The cliff wall by the side gate to the Cathedral has two old **stone sights** embedded in it; the western one points at the lighthouse. Also known as the **Inchcape Rock**, this shipping hazard is famous from Robert Southey's poem (1820).

Notes: Construction, including mathematical shape:

http://www.bellrock.org.uk/lighthouse/lighthouse_construct.htm ; poem

http://www.bellrock.org.uk/misc/misc_poem.htm



Shape of the Bell Rock Lighthouse: Sketches of possible lighthouse profiles from Robert Stevenson's 'An Account of the Bell Rock Lighthouse' (1824). Stevenson suggested the Paraboloid (fig.3), but Rennie preferred a shallower curve, Possibly the Cycloidal (fig.1)

14. Harbour and pier. Its heyday was in the 15th and 16th century, when the fleet comprised up to 50 boats, but fishing made a significant contribution to St Andrews' economy until the 20th century. The medieval pier was rebuilt in stone in 1559 and renewed many times.

15. Gatty Marine Laboratory, opened in 1896 to succeed the St Andrews Fisheries Laboratory. Both were founded by **William McIntosh** (1838-1931), prompted by the need

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to understand the life histories of fish in connection with the introduction of steam powered trawling – which was of great concern at the time and the labs were funded by the Scottish Fisheries Commission. McIntosh conducted experiments on the life-cycle of fish (especially the depth in the water at which they laid their eggs), and concluded that the fishing methods then available could not impoverish fish stocks – in opposition to the findings of developing environmental statistical methods in Scotland and Scandinavia (which gathered data using capture, mark and re-capture techniques – but they used a boat that was of a completely different design to a steam trawler so McIntosh thought the results not relevant). This increasing opposition led to loss of Fisheries Commission funding, and when D’Arcy Thompson succeeded McIntosh as Professor of Natural History, he tried to close the Gatty down. But McIntosh hung in there, in retirement until his death in 1931, despite lack of heating etc. Eventually the Gatty was revived on the initiative of xxx Graham, the Professor of Botany, after World War II.

16. David Brewster’s House, Principal of St Andrews 1837-1859. Best known as the inventor of the kaleidoscope and an early developer of photography, Brewster (1781-1868) made major contributions to the field of optics, including the connection between refractive index and polarising angle, biaxial crystals, and the production of double refraction by irregular heating. He described the dioptric lens system, generally attributed to Fresnel, in 1812, and was largely responsible in getting it adopted by British lighthouses. He was a founder of the British Association (as was Forbes), and Forbes’ mentor and senior. I suspect that it was because Brewster was here that St Andrews became such a centre of early photography. Brewster had good contacts with all the chief scientists and photographers of the day. His house, was subsequently occupied by the mineralogist **M. Forster Heddle** (1828-1897), and is now part of St Leonard’s School.

17. George Martine’s house at 36-42 South St. Martine the elder (1635-1712) wrote the first history of the Archbishopric of St Andrews, later translated by **John Rotheram**, (1750?-1804) Linnaeus's only English student, assistant to Joseph Black, and later professor of Natural Philosophy at St Andrews. **George Martine** the younger (1700-1741) made the first estimate of absolute zero, suggested the earth must have an internal source of heat, and performed the first tracheotomy in Britain here. Go through the arch to **James D. Forbes’ house**. A natural philosopher best known as a glaciologist, and for work on heat (demonstrating that radiant heat could be polarised and hence arguing that it was akin to light), Forbes (1809-1868) was an early adopter of curve plotting. He beat his mentor and much better established scientist, Brewster, to the Chair of Natural Philosophy at Edinburgh in 1833, but succeeded Brewster as Principal of St Andrews in 1859 (when Brewster became Principal of Edinburgh University) – at the time Forbes was suffering from tuberculosis (of which he died 9 years later) and was looking for an easy job (the university had only about 80 students). While at Edinburgh, Forbes taught both P.G.Tait and Maxwell. Tait, in particular, became a strong champion of Forbes’ in various controversies about glaciers.

18. D’Arcy Wentworth Thompson's house in a traditional “lang rig” at 44 South St. Thompson (1860-1948, Professor of Natural History from 1917) pioneered mathematical methods in biology. *On Growth and Form* (1917) stressed the way physical laws and mechanics determined form, promoting scientific explanation of the processes by which

patterns are formed in plants and animals (i.e. evolution wasn't everything). In gym shoes, with parrot on shoulder, he was a distinctive figure around town.

Noteshttp://www-history.mcs.st-and.ac.uk/Biographies/Thompson_D'Arcy.html ;
https://en.wikipedia.org/wiki/D%27Arcy_Wentworth_Thompson .

19. Bute Medical School. Completed in 1899, the Bute provided the first medical teaching in St Andrews. Previously, since the 17th century, the University awarded MD degrees purely on the basis of a testimonial and fee – a system that became highly controversial in the 19th century.

20. St Mary's College was founded by Archbishop James Beaton in 1539 and the buildings date from this time, though they have been remodelled since. Go through the arch to see the cube **sundial** in the garden, erected by Principal Walter Comrie in 1664. “**Parliament Hall**”, where the Scottish parliament met in 1645 is to the east of the arch. **James Gregory** (1638-1675) used the **King James Library** above Parliament Hall as an observatory. Gregory invented the first practical reflecting telescope, discovered the diffraction grating, and was a co-founder of calculus. The support for his transit telescope is in a south-facing window. His meridian, defined in the 1670s with an accuracy of better than one part in 2000, not surpassed until the Greenwich meridian nearly a century later, is marked in the pavement outside Parliament Hall.

Notes: Gregory's meridian

<http://www.tandfonline.com/doi/full/10.1080/17498430802019804?scroll=top&needAccess=true&instName=University+of+St+Andrews> (most easily accessed from on campus, or ask me for a copy). Summarised in Peter Cameron's blog re the meridian and the pillar
<https://cameroncounts.wordpress.com/2013/04/28/gregorys-pillar/>

Gregory: <http://www-history.mcs.st-and.ac.uk/Biographies/Gregory.html> ;
[https://en.wikipedia.org/wiki/James_Gregory_\(mathematician\)](https://en.wikipedia.org/wiki/James_Gregory_(mathematician));

Gregory worked in the University Library because he was a University, rather than a College employee, and the library was the only suitable university premises. He constructed a university observatory at the south end of Westburn Lane, but left for Edinburgh before it was completed. The building was demolished in the nineteenth century.

21. J&G Innes (“The Citizen Shop”) became home to the local newspaper in 1890. The site has been associated with printing since 1622. a long association with printing; Edward Raban's works were probably here in 1622, as were those of Bailie Bell (father of Andrew, q.v.) who, before 1744, worked with Alexander Wilson to perfect Scottish typefounding. The shop front was renovated in 1927.

22. John Adamson's house. A physician, friend of David Brewster's, and pioneer of photography, Adamson (1809-1870) took the first calotype portrait in 1841. His family home at 127 South St later became the main town post office and is now a restaurant.

23. Blackfriars Chapel. The chapel was built in 1525 but all that remains is the unusual semi-octagonal north transept. The rest of the chapel was destroyed by protestant reformers in 1559; legend has it following an inflammatory sermon by John Knox. Behind the chapel is **Madras College**, founded by Andrew Bell (1753-1832), a local man who became chaplain to

the East India Company in Madras. He invented the “Madras” or “monitor” system whereby older boys taught younger pupils. His will specified that the building should harmonise with the Blackfriars Chapel. It is now the local comprehensive school. **William Oughter Lonie** taught mathematics at Madras 1846-1888, where he was viewed as an educational reformer. (“He did not insist on the dry and rigid demonstrations of Euclid. He dealt with mathematics not as an exercise of memory but as an effort of intelligence and reason”). We know quite a lot about his teaching since the *Fair Book of James Walker* written while taking Lonie's classes, survives in the University's Special Collections; he also gave evidence to Parliamentary Enquiries about maths teaching and we have that also. Lonie achieved international recognition with his book *Practical Stereoscopic Photography* (1856), which was endorsed by David Brewster (q.v.)

Note: <http://www-history.mcs.st-andrews.ac.uk/Biographies/Lonie.html> ; http://www-history.mcs.st-andrews.ac.uk/Extras/Brown_Lonie.html

Oughter Lonie either lived or operated from/taught in a house in Greyfriars Gardens (then North Bell St. Lonie was at no. 5, but I don't know which end that was, most likely the south end).

At the time, Madras had about 1000 pupils – the University had 80 students !!!

24. Thomas Rodger's house and studio. Persuaded to take up photography by John Adamson (q.v.), Rodger (1832-1883) was the first professional photographer in St Andrews. He became famous for his portrayals of the town, its people, and eminent visitors.

25. The Blue Stane, is a glacial erratic of dolerite from Drumcarrow Craig. It has moved several times within the town, serving as a focus for meetings and oath taking before ending up in its current location in the forecourt of the pub of the same name.

26. The West Port was built in 1589 by John Robertson, replacing an earlier gate. It was modelled on Edinburgh's Netherbow Port. It was renovated in 1843-45 when the pedestrian arches replaced the guardhouses and fresh carvings were added to the west face.

27. Lade Braes walk. The lade, which dates back to the 13th century, supplied water and power to the priory and various mills along its one mile route; it followed the backs of the lang rigs whose dykes formed the town boundary. The lade was covered over in the late 19th century and planted with trees and shrubs as a recreational path by Bailies John Milne and John McIntosh.

28. St Andrews museum, Kinburn Castle, open daily 10.00-17.00

29. Orrery, made by Benjamin Cole of London between 1748 and 1760. It is unusual in having windows in the base so that the mechanism can be seen. The orrery is half way up the main stairs in the Physics Department, with no access at weekends.

30. Botanic Gardens, founded in 1889 by **John Wilson** to support his botany lectures with beds set out by the Bentham Hooker classification. Originally near the Bute Medical School (q.v.), the Gardens, including mature trees, moved to the current site in 1962. Open daily, 10.00-19.00

31. The University Observatory houses the largest operational optical telescope in the UK. This is the “Gregory telescope”, the first full size (0.94m) Schmidt-Cassegrain telescope built.

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Fitted with a CCD camera it monitors the brightness variations of stars, active galaxies, and transiting planets.

32. Gregory's Pillar, on a hill south of town, marks the far end of Gregory's meridian (q.v.)

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