65.3 A pi-Less Area
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Team		Goals Scored						
		0	1	2	3	4	5	≥6
Middlesbrough	Observed	11	14	12	4	0	0	1
	Expected	11	15	10	4	1	0	0
Norwich	Observed	12	15	10	4	1	0	0
	Expected	12	15	9	4	1	0	0
Nottingham F.	Observed	11	14	8	7	1	0	1
	Expected	10	14	10	5	2	1	0
Q.P.R.	Observed	11	23	4	3	0	1	0
	Expected	14	15	8	3	1	0	0
Southampton	Observed	14	14	10	3	1	0	0
	Expected	14	15	9	3	1	0	0
Tottenham H.	Observed	12	17	8	5	0	0	0
	Expected	13	15	9	3	1	0	0
W.B.A.	Observed	5	19	9	5	2	1	1
	Expected	8	13	11	6	3	1	0
Wolverhampton W.	Observed	12	20	7	2	1	0	0
	Expected	15	15	8	3	1	0	0

When these twenty-two sets of results are tested at the 5% level of significance using a chi-square distribution only one set, namely that associated with Q.P.R., will not support the hypothesis that the data is a Poisson distribution. However, this transgression by Q.P.R. did not go without penalty as they were relegated!

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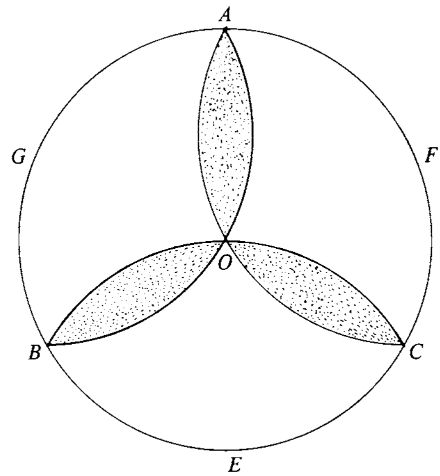
Although in pure mathematics elaborate pathological examples can be constructed to illustrate apparently unexpected results, it does come as a surprise, now and then, to see such results in simple cases. For example, consider the well-known example of two equal right circular cylinders whose axes intersect at right angles. What is the volume of the region common to the two cylinders? A simple calculation shows the answer to be $16a^3/3$ where a is the radius of each cylinder. That a region surrounded by cylindrically curved surfaces should have a volume independent of π does come as a surprise.



Here we illustrate another example, relating to areas. The three-petal lotus shown in the figure is one which every child, learning to use the compass, is taught to draw. What is the area of the *unshaded* region within the circle? Although surrounded on all sides by arcs of circles, the answer is independent of π—as the simple calculation shows below.

The petal OA is bounded by the arcs of two equal circles centred at F and G. Taking the radius OA of the full circle as equal to a, the area of petal OA is given by

$$X = a^2\left(\frac{\pi}{3} - \sin\frac{\pi}{3}\right) = \left(\frac{\pi}{3} - \frac{\sqrt{3}}{2}\right)a^2.$$

The unshaded area is therefore given by

$$Y = \pi a^2 - 3X = \frac{3\sqrt{3}}{2}\,a^2.$$

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Intuition

"I have had my solutions for a long time, but I do not yet know how I am to arrive at them." (Gauss)

"It's plain to me by the fountain that I draw from, though I will not undertake to prove it to others." (Newton)

Quoted in W. M. Priestley, *Calculus: an historical approach* (per E. H. Lockwood).