2. M. Bataille, Another simple construction of the golden section, *Forum Geometricorum* **11** (2011) p, 55.
3. D. Dobre, Mathematical properties of the golden ratio – a fascinating number, *Journal of Industrial Design and Engineering Graphics* **8** (2013) pp. 11--16.

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99.23 Kicking a cube

By tradition Adidas releases a new football for each FIFA World Cup. Previously we considered the geometry of the underlying polyhedra, formed by the seams and their intersections, in two of these footballs [1, 2]. Continuing our football-geometry theme we ask, 'What is the name of the underlying polyhedron of the 2014 World Cup football, Brazuca?'

The most obvious panels of the new ball are white, and each has the appearance of a four-bladed propeller; there are six of them (Figure 1). They appear to interlink with eight curvilinear black triangles that have images of four-pointed stars scattered within them. Yet on close inspection each triangle has three seams that merge at its centroid, making what is formally a vertex there. Following the seams around the ball (and checking the description on the Internet [3]) confirms that there are only six panels. These are made up of curved and straight sections, and all six curvilinear polyhedra are the same.

So, 'What regular polyhedron, which is drawn with straight lines that replace the curved ones on the ball, has six faces of which only three meet at each of eight vertices?' It is defined in terms of the Schläfli symbol as {4,3}, meaning 4-sided polygons meet at each vertex, and three of them do so [4]. The answer is a cube! Of course, this is one of the classical Platonic 'solids' [4, 5]. So there is no need to hunt for a systematic name as was the case for Jabulani [2], or to construct a Schlegel diagram [4] to help understand the symmetry of the body. Its 'picture frame' diagram is already well known [4,5].

We might have been tempted into thinking that the underlying regular polyhedron consisted of eight triangles and six squares thus making it a cuboctahedron [6]; but the intersection of the seams in the black triangles means that the triangles are a superficial distraction to the geometer.

Obviously, modern moulding technology renders the six panels into sections of a sphere and generates a football that has even fewer panels than its predecessors. This is not what might have been expected if we thought that the more panels there are the better the approximation is to a sphere; but this was before we acknowledged that moulding of plastics yields a higher level of sphericity than panels that are stitched together … hence Adidas's ability to 'sphere the cube'.

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References

1. P. W. Kuchel, Can you 'bend' a truncated octahedron? *Math. Gaz.* **91** (November 2007) pp. 533-536.
2. P. W. Kuchel, Can you 'bend' a truncated truncated tetrahedron? *Math. Gaz.* **96** (July 2012) pp. 317-323.
3. http://en.wikipedia.org/wiki/Adidas_Brazuca
4. H. S. M. Coxeter, *Introduction to geometry* (2nd edn.) John Wiley & Sons (1969).
5. H. M. Cundy and A. P. Rollett, *Mathematical models*, Oxford University Press (1972) Chap III.
6. P. W. Kuchel, $10n^2 + 2$ revealed. *Math. Gaz.* **92** (December 2008) pp. 546-551.



FIGURE 1: Brazuca football

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99.24 The Not-on-the-line transformation

'My credibility is not on the line.' President Barack Obama.

In two dimensions, let us define a line $L_0 = 0$ not through the origin, where $L_0 = ax + by + c$, $c \neq 0$. Now choose a point $R(p, q)$ with $p \neq 0$, $q \neq 0$, that does NOT lie on $L_0 = 0$. We will also insist that $ap \neq bq$, for reasons that will become clear. We can define a transformation T as follows: suppose R DOES lie on each of the three lines

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