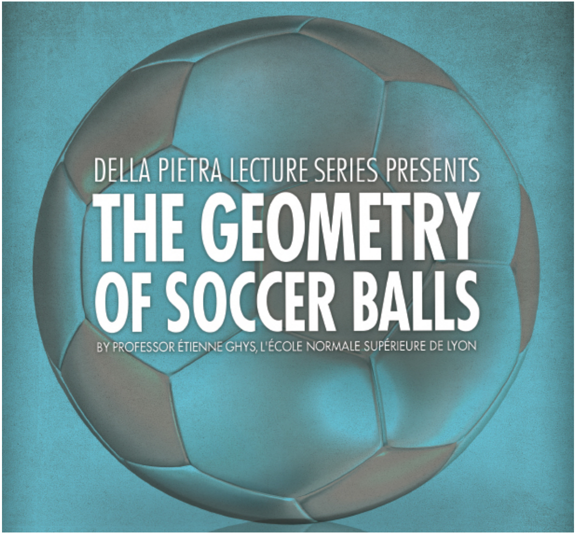

DELLA PIETRA LECTURE SERIES PRESENTS
THE GEOMETRY
OF SOCCER BALLS
BY PROFESSOR ÉTIENNE GHYS, L'ÉCOLE NORMALE SUPÉRIEURE DE LYON

Brazuca : The official World Cup Soccer ball : 2014

Brazuca : The official World Cup Soccer ball : 2014

Oldest Soccer ball

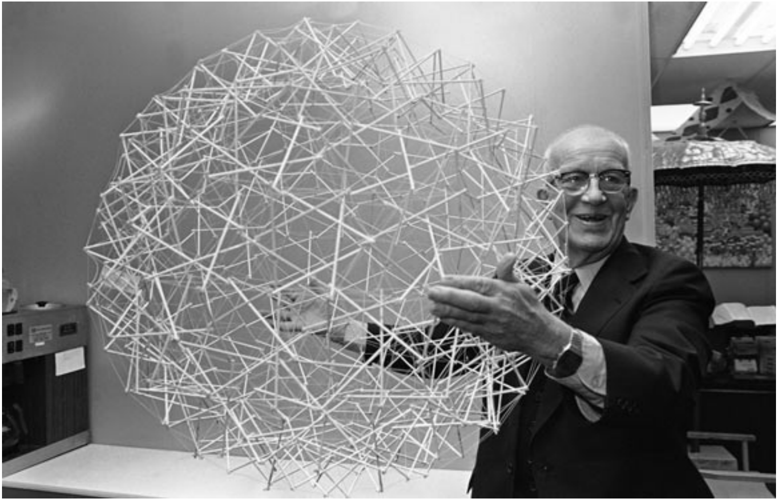
FIFA (Fédération Internationale de Football Association)
Laws of the Game

Law 2 - The Ball. Qualities and Measurements. The ball is :

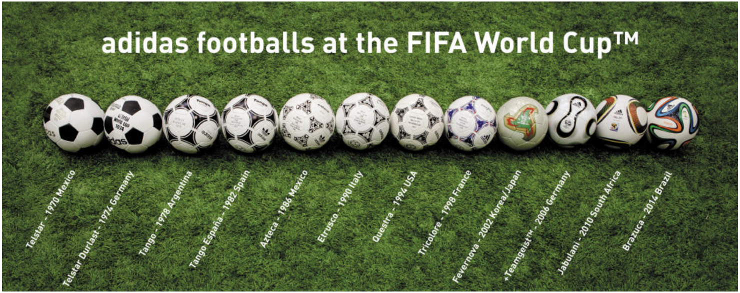
- spherical
- Made of leather or other suitable material
- Of a circumference of not more than 70 cm (28 ins) and not less than 68 cm (27 ins) not more than 450 g (16 oz) in weight and not less than 410 g (14 oz) at the start of the match of a pressure equal to 0.6 – 1.1 atmosphere (600 – 1100 g/cm 2) at sea level (8.5 lbs/sq in to 15.6 lbs/sq in)

Telstar : World Cup Mexico 1970, Buckyball

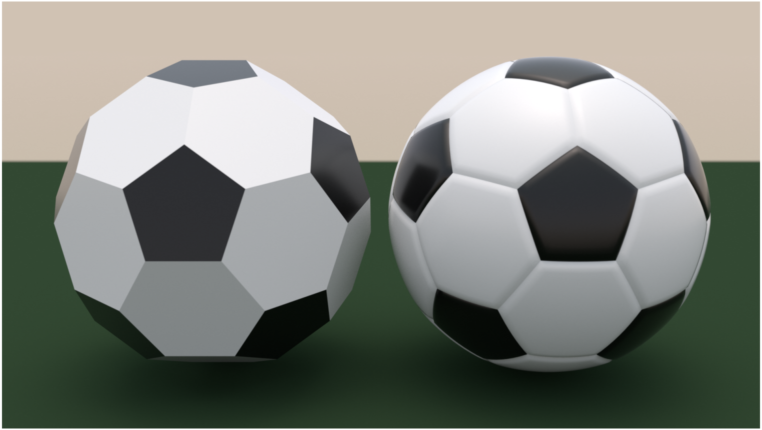
Richard Buckminster Fuller (1895-1983)

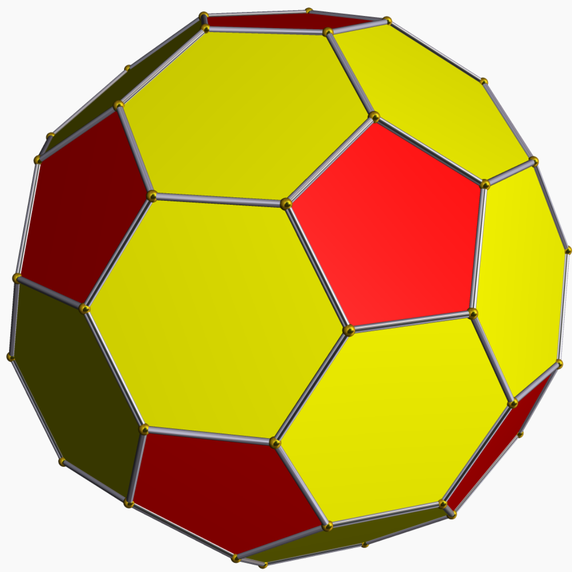


Richard Buckminster Fuller (1895-1983)

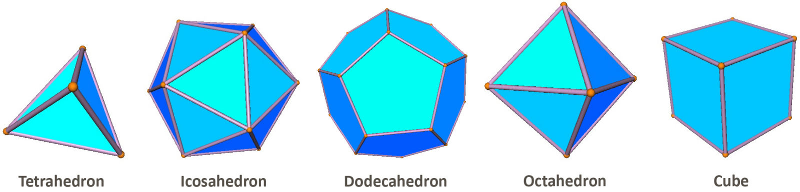

adidas footballs at the FIFA World Cup™
Telstar - 1970 Mexico
Telstar Durlast - 1974 Germany
Tango - 1978 Argentina
Tango España - 1982 Spain
Azteca - 1986 Mexico
Etrusco - 1990 Italy
Questra - 1994 USA
Tricolore - 1998 France
Fevernova - 2002 Korea/Japan
+Teamgeist™ - 2006 Germany
Jabulani - 2010 South Africa
Brazuca - 2014 Brazil

Twenty hexagons and Twelve pentagons

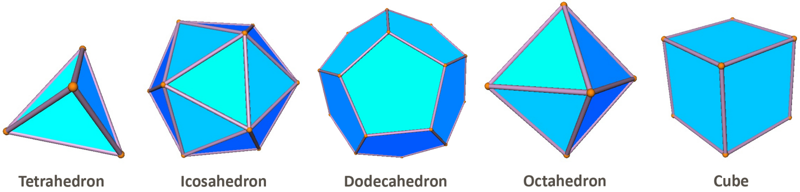




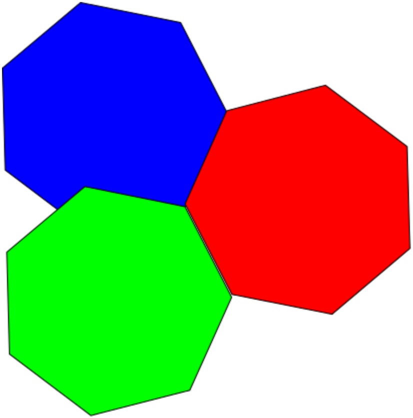
Five platonic solids



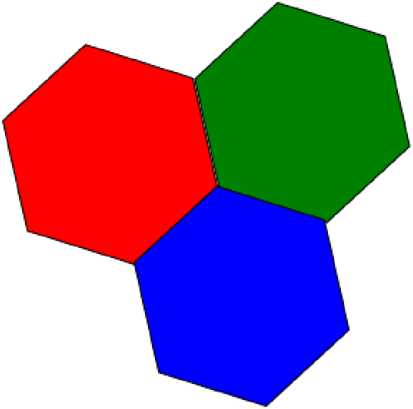
Five platonic solids



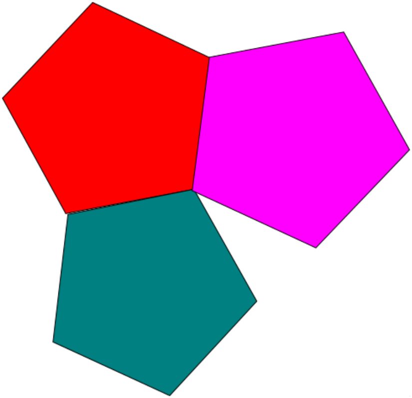
Three regular heptagons don't fit



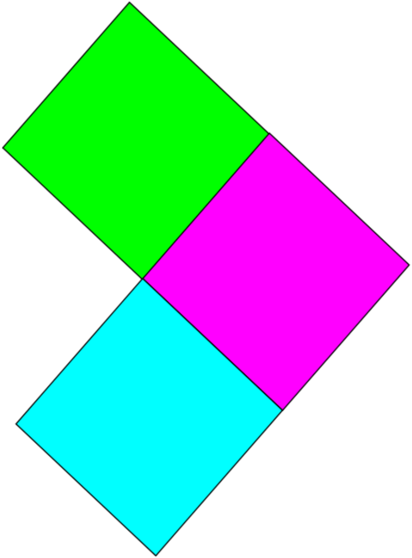
Three regular hexagons



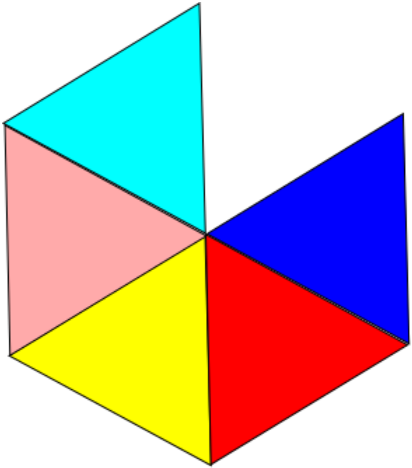
Regular pentagons



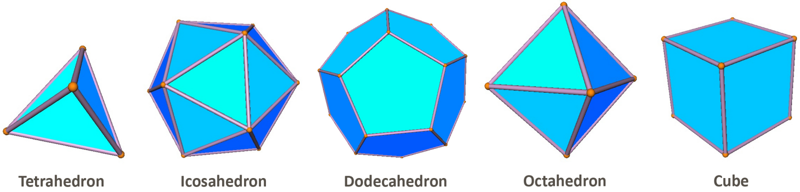
Squares



Equilateral triangles



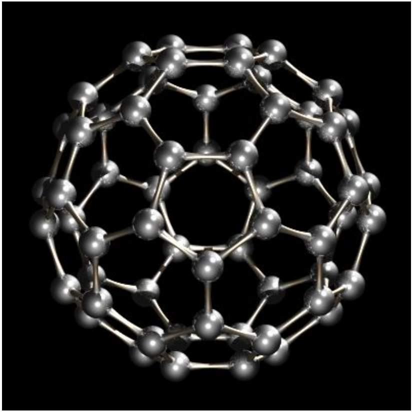
Five platonic solids



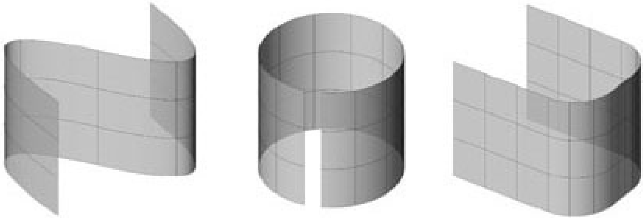
Building a dodecahedron

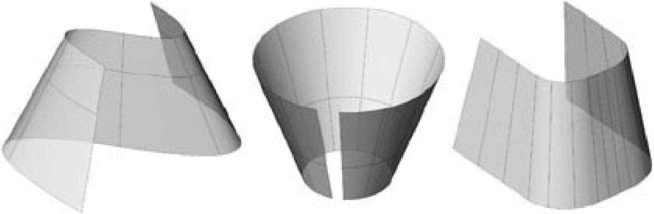
Truncation of a dodecahedron

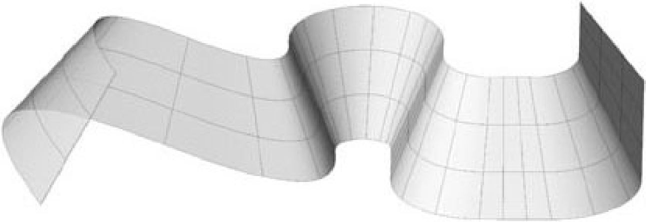
Buckminsterfullerene

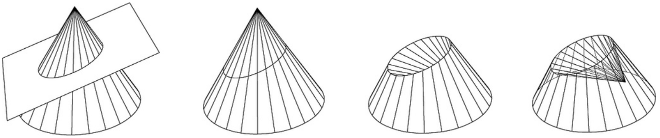


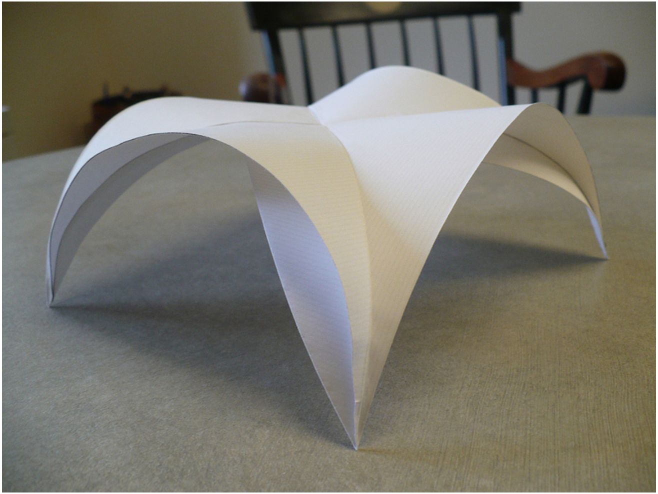
It could be an idea to bend the faces of the polyhedron ?

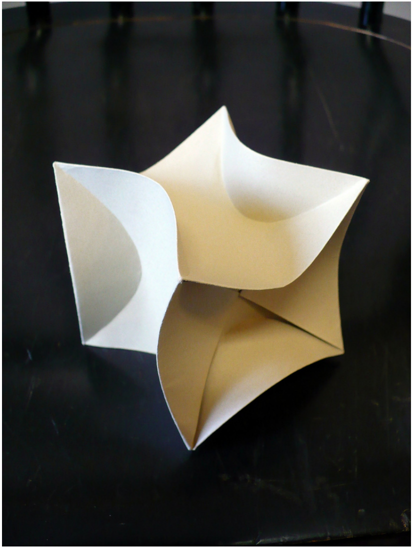


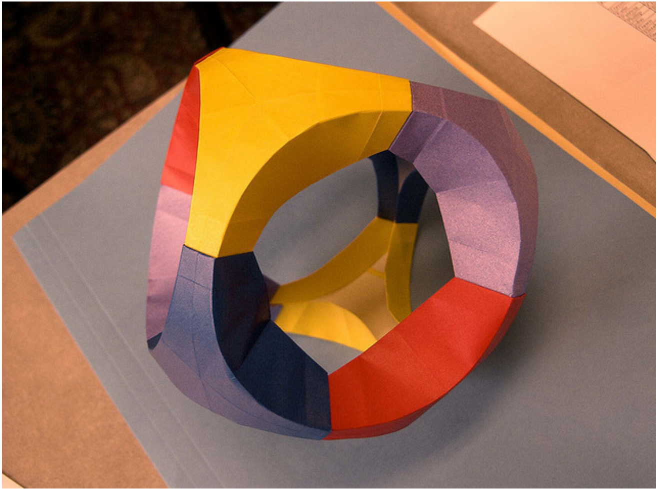




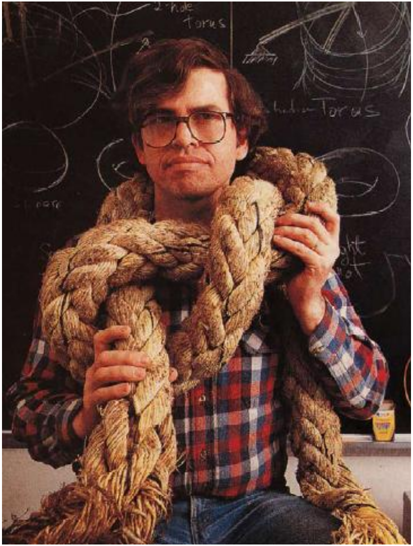




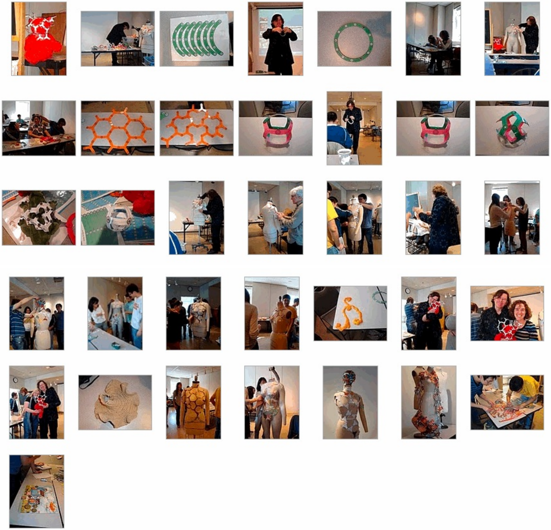




William Thurston



William Thurston



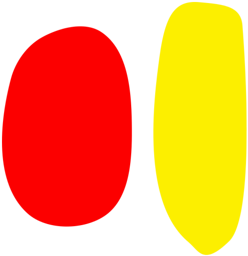
William Thurston

William Thurston

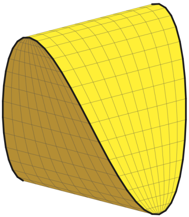
hyperbolic-crochet

hyperbolic-crochet

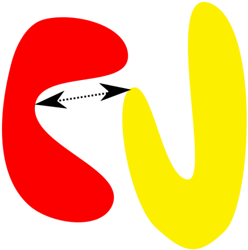
Theorem (Alexandrov Pogorelov 1970) : *Start with two convex domains with the same perimeter. Glue them along their boundaries (respecting the arc lengths).*



Theorem (Alexandrov Pogorelov 1970) : *Start with two convex domains with the same perimeter. Glue them along their boundaries (respecting the arc lengths).*



Theorem (Alexandrov Pogorelov 1970) : *The same is true if the two domains are not convex but if the sum of the two curvatures at points which are identified is positive.*



Playing with Surfaces:
Spheres, Monkey Pants, and Zippergons

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Cornell University
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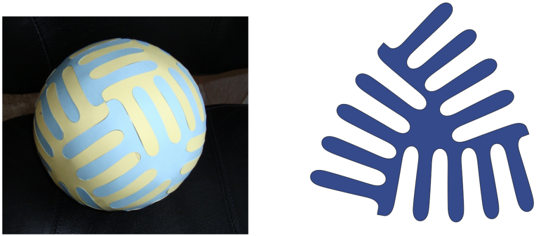
Abstract

We describe a process, inspired by clothing design, of smoothing an octahedron to form a round sphere. This process can be adapted to construct many different surfaces out of paper and craft foam.

Introduction

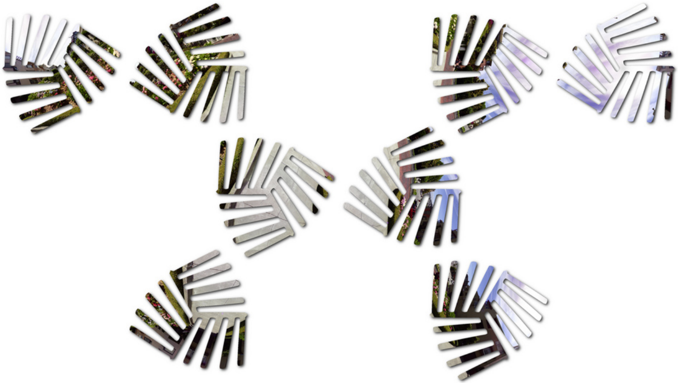


(a) *Paper and tape model* (b) *Pattern*

Figure 1: *Octahedral Sphere*

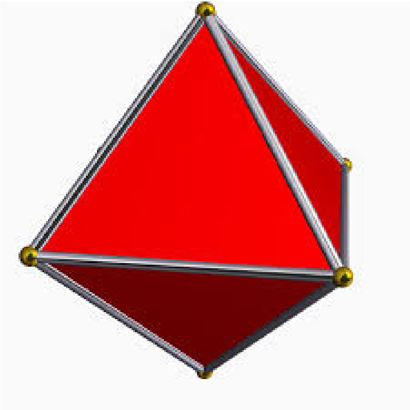
Kelly Delp, William Thurston, Bridges Coimbra Conference Proceedings (2011), 1-8.

Delp - Thurston



Flicker David Swart

Octahedron



Delp Thurston

Delp Thurston

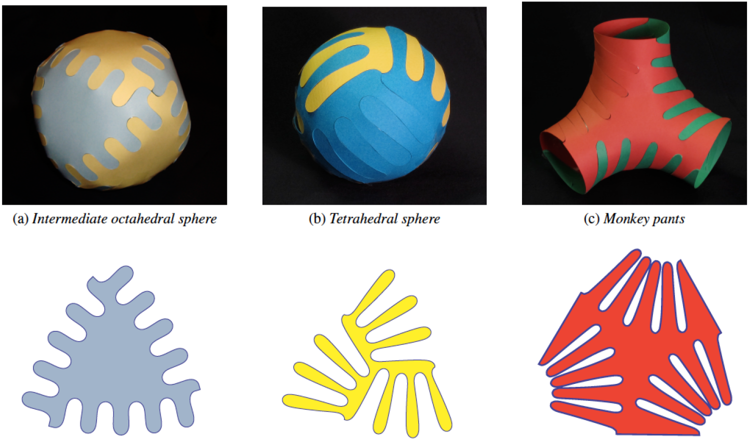


Figure 5: *Paper Models*

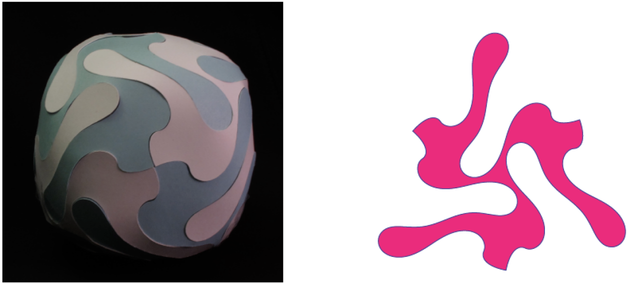
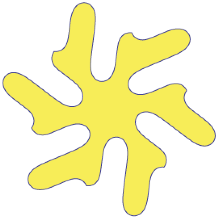


Figure 6: *Octahedral sphere II*

Zippergons

(a) 120° *pentagon*



(b) 120° *hexagon*

(c) 120° *heptagon*

Figure 7: *Three per vertex system*

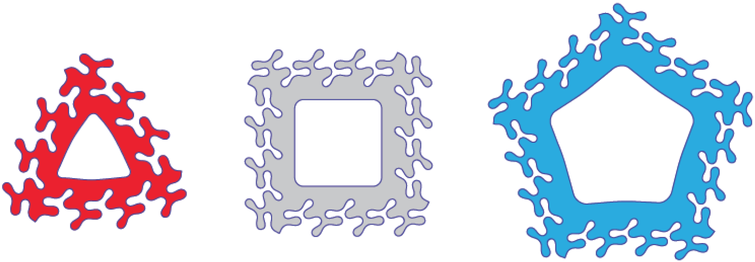


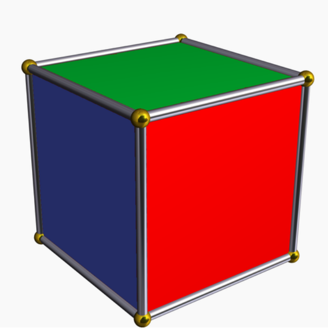
Figure 9: *Improved Zippergons*

(a) *Cuboctahedron* (b) *Icosadodecahedron* (c) *Negative curvature*

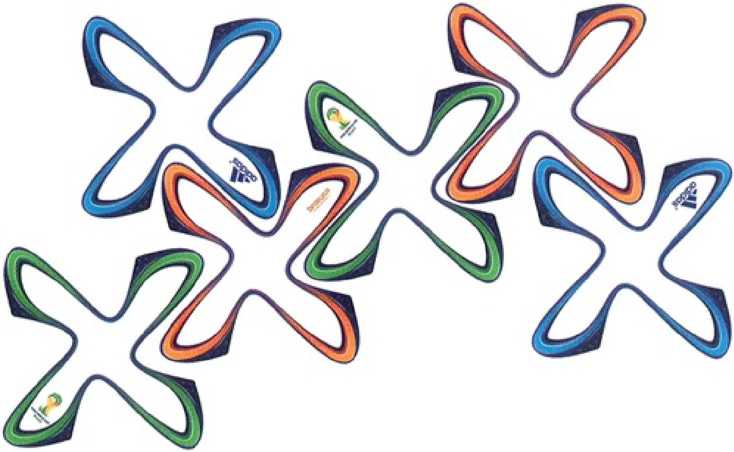
Figure 10: *Tapeless Zippergon constructions*

Brazuca : FIFA World cup 2014

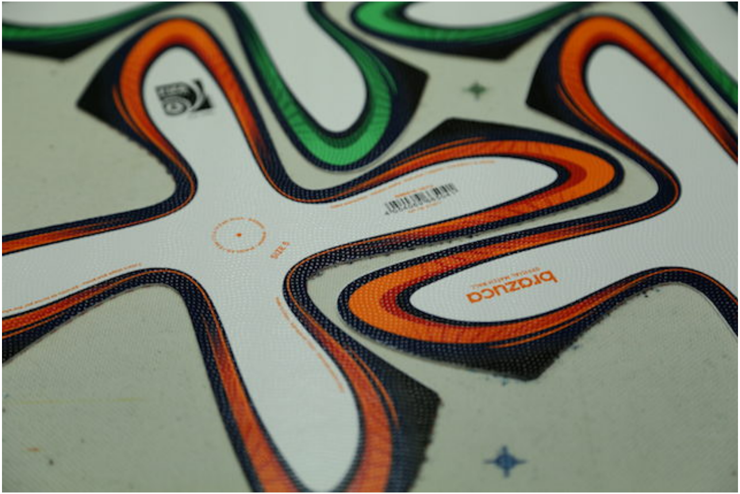
Brazuca : FIFA World cup 2014



Brazuca : FIFA World cup 2014



Brazuca : FIFA World cup 2014

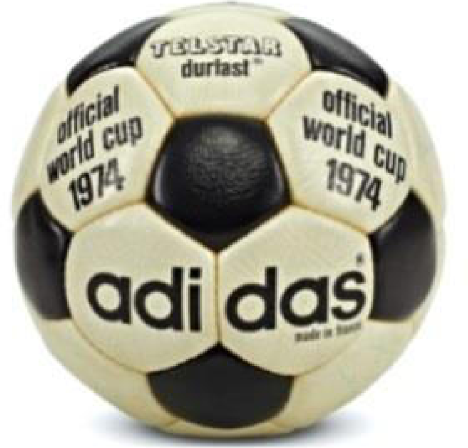


Brazuca : FIFA World cup 2014

Brazuca : FIFA World cup 2014

Telstar Mexico 1970

Telstar Germany 1974



Tango Argentina 1978

Tango Spain 1982

Azteca Mexico 1986

Etrusco 1990 Italy

Questra 1994 USA

Tricolore France 1998

Fevernova 2002 Japan

Teamgeist 2006 Germany

Jabulani 2010 South Africa

Brazuca 2014 Brazil

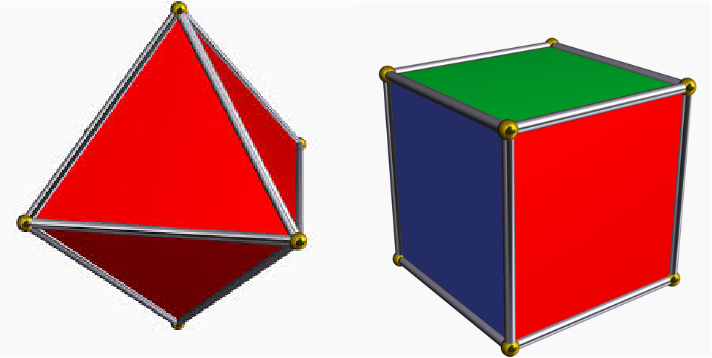
Teamgeist 2006 Germany

Teamgeist 2006 Germany : : 14 panels

Teamgeist 2006 Germany : Six bean shaped panels

Teamgeist 2006 Germany : Eight hexagonal panels

The cube and the octahedron are dual

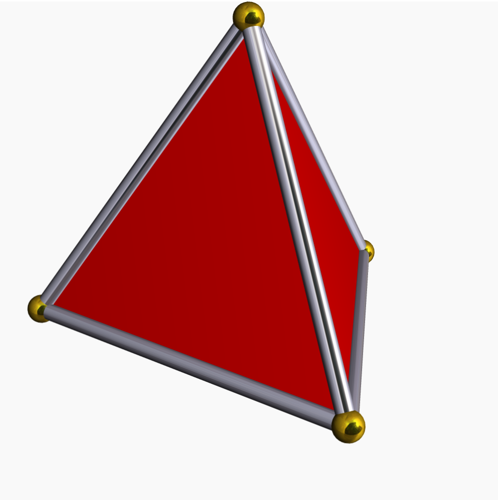


Teamgeist 2006 Germany

Jabulani 2010 South Africa

Jabulani 2010 South Africa

Jabulani 2010 South Africa : a self dual tetrahedron



Physics is important too !

Effect of panel shape of soccer ball on its flight characteristics

Sungchan Hong & Takeshi Asai

Affiliations | Contributions | Corresponding author

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Soccer balls are typically constructed from 32 pentagonal and hexagonal panels. Recently, however, newer balls named Cafusa, Teamgeist 2, and Jabulani were respectively produced from 32, 14, and 8 panels with shapes and designs dramatically different from those of conventional balls. The newest type of ball, named Brazuca, was produced from six panels and will be used in the 2014 FIFA World Cup in Brazil. There have, however, been few studies on the aerodynamic properties of balls constructed from different numbers and shapes of panels. Hence, we used wind tunnel tests and a kick-robot to examine the relationship between the panel shape and orientation of modern soccer balls and their aerodynamic and flight characteristics. We observed a correlation between the wind tunnel test results and the actual ball trajectories, and also clarified how the panel characteristics affected the flight of the ball, which enabled prediction of the trajectory.

Subject terms: Mechanical engineering • Fluid dynamics


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