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what's the point of...

QUADRATIC EQUATIONS?

The Beautiful Game? Oh ballistics...

There will always be debate about issues in football. Who scored the best goal? The best ever player? The best team?

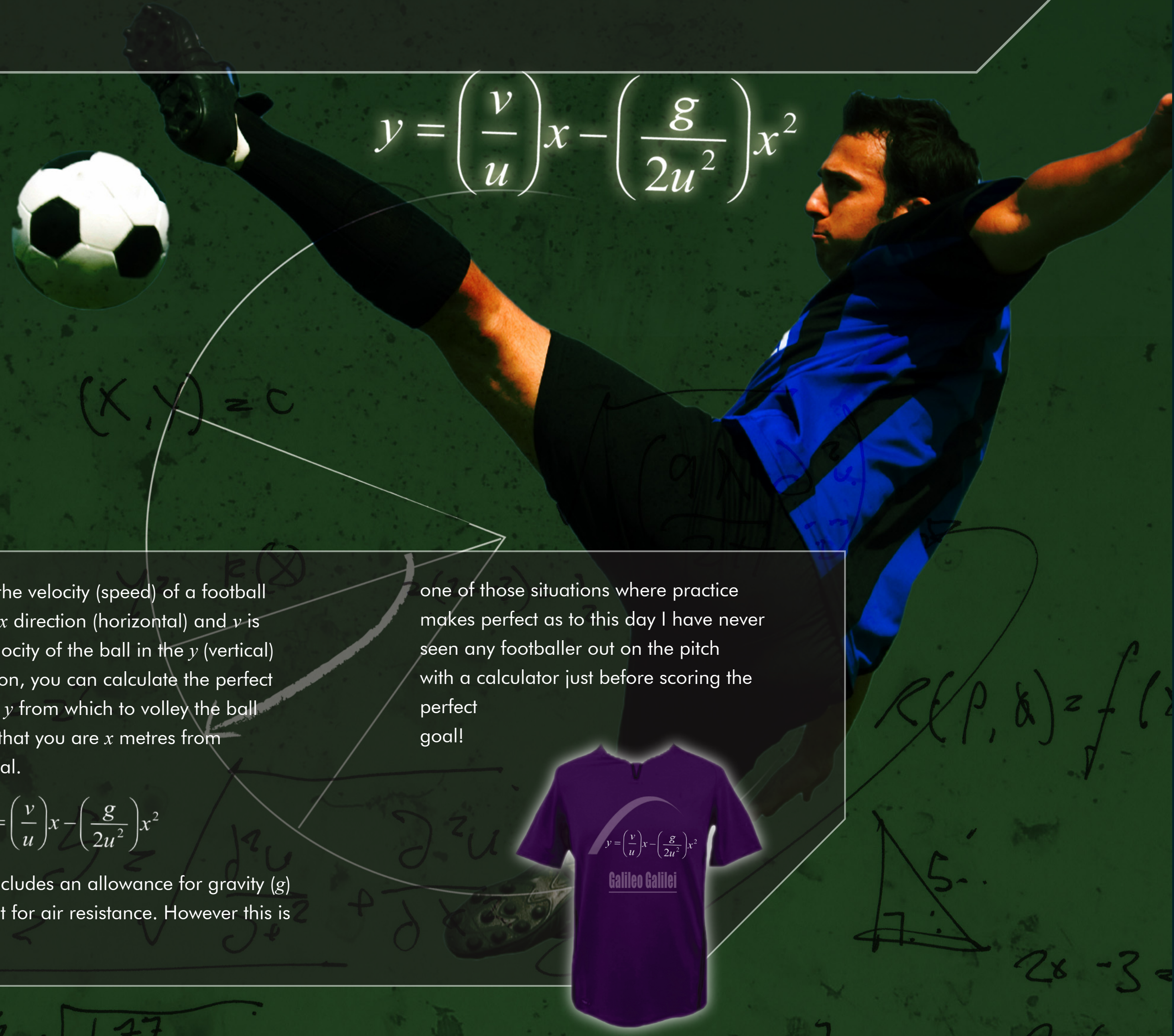
These debates will take up many hours and there will never be an outright winner, although Brazil and Liverpool are my choices – and I'm always right!

However there is no debate about one of the most technically gifted players of the modern era, Zinedine Zidane, who scored arguably the best ever goal in 2002 in the UEFA Champions League Final.

How did he do it?

Well, quadratic equations may help to explain the art of the volley. The principles are based on discoveries by Galileo and have many implications for military and sports enthusiasts alike.

$$y = \left(\frac{v}{u}\right)x - \left(\frac{g}{2u^2}\right)x^2$$



If u is the velocity (speed) of a football in the x direction (horizontal) and v is the velocity of the ball in the y (vertical) direction, you can calculate the perfect height y from which to volley the ball given that you are x metres from the goal.

$$y = \left(\frac{v}{u}\right)x - \left(\frac{g}{2u^2}\right)x^2$$

This includes an allowance for gravity (g) but not for air resistance. However this is one of those situations where practice makes perfect as to this day I have never seen any footballer out on the pitch with a calculator just before scoring the perfect goal!

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Crime Scene Mathematics

Quadratic equations have also been applied to the saving of lives and the analysis of crime scenes.

When a forensics team reaches a crime scene where bullets have been fired, the application of quadratics helps to determine where a bullet was fired from.

When investigators arrive at the scene of a car crash they can work out the speed of the car at the time of the accident and make judgements on dangerous driving, etc. A car can travel from A to B by travelling at a constant speed. However in order to reach that speed it must accelerate and, using common sense, in order to stop it must decelerate (braking).

Where s is the distance travelled by a car, u is the velocity of the car, a is the acceleration and t is the time, we have a quadratic equation that links s to t.

$$s = ut + \frac{1}{2}at^2$$

If we substitute a negative value for a, then we can model deceleration and hence braking distance s. This simple equation predicts that by doubling your speed it will quadruple your stopping distance.

$$s = \frac{u^2}{2a}$$

It makes sense to drive safely – and the maths proves it …

Raindrops keep falling on my head... but satellites don't

Let's perform a simple experiment. You throw a tennis ball in the air and (hopefully without hitting anyone) it should come back down having followed a parabolic path after obeying the laws of gravity. This path is essentially a quadratic equation with a negative coefficient for x^2 (why?).

In this age of rapid technological advances, we are continually and increasingly reliant on satellite technology. Without satellites there wouldn't be international mobile phone conversations, access to thousands of media channels, personal navigation systems, weather monitoring, etc. So why aren't satellites falling on our heads like the tennis ball? Think about a satellite being launched. Let's assume the Earth is stationary and completely flat along the x axis. At some point the satellite will fall back down to Earth, and this would be the range of the satellite. However the Earth is spherical, not flat, so the position of the x axis changes as we move around the Earth.

To try to understand this, draw a series of regular polygons by increasing the number of sides, n, each time by one (triangle, square, pentagon, hexagon, etc.). The more sides to the shape, the more it resembles a circle. In fact, consider a polygon with infinite sides. What shape is this? Each of the sides can be thought of as being the x axis but from a different point along the Earth's surface.

Every time the satellite reaches its range (where you expect it to land if the Earth had a flat surface), it actually hasn't. It will miss the edge because the Earth has a curved surface and so it has new x axis position. Furthermore, with the Earth actually rotating, a satellite can be launched to a precise height and speed to maintain geostationary orbit, appearing as if it were stationary above the same point on the Earth's surface, whilst actually keeping pace with the Earth's rotation. If we didn't have this, we would keep losing satellite TV feeds and end up watching less TV.

Now there's a thought …