# Ball Flight Solver

Drag, gravity and Magnus integrated properly, with a drag coefficient that changes through the crisis.

Fourth-order Runge-Kutta at two-millisecond steps, a speed-dependent drag coefficient per ball model, spin decay, wind and air density, with helpers for free kicks, serves and shots.

| SPORT | FAMILY | LICENCE |
|---|---|---|
| Football, tennis, basketball | Sports physics | £449 one-off, perpetual |

**RUNNING IN THE PLATFORM**
https://edgeworthарena.com/arena/api/physics/free-kick?speed=27&elevation=13&side_rpm=800

## Inputs

| NAME | TYPE | UNITS | WHERE IT COMES FROM |
|---|---|---|---|
| speed, elevation, azimuth | floats | m/s and degrees | your launch conditions |
| spin | float | rpm | side and top components |
| ball | object | mass kg, radius m, C_d curve | the catalogue, or your own measurements |
| air (optional) | floats | kg/m³, m/s | density from altitude and temperature; wind vector |

## Outputs

| NAME | TYPE | UNITS | NOTES |
|---|---|---|---|
| path | array of (t, x, y, z) | s, m | |
| crossing | position at a plane | m | the goal line, the service line, the rim |
| flight_time, peak | floats | s, m | |

## Method

1 Integrate m dv/dt = mg − ½ρC_d A |v| v + ½ρC_l A |v|² (ω̂ × v̂) with RK4.

**THIS IS THE SAMPLE**
The method runs to 4 steps; one is shown. The assumptions, the limits, the module layout and the reference implementation come with the licence. Everything on the page below this -- what the model was measured at -- is the same in both versions, because that is the part you should not have to take on trust.

## What it was measured at

Computed now, with the solver the films run on.

| MEASURE | RESULT | READING |
|---|---|---|
| Integrator | RK4 at 2 ms | the step at which the path stops changing |
| Bend from 800 rpm over 22 m | 3.00 m | same launch, spin the only difference |
| Drag crisis law | exponent -0.33, $R^2$ 0.56 | fitted on 6 wind-tunnel balls |
| Unmeasured balls | predicted with a ±20% band | rather than asserted |

## Assumptions

What has to be true for the numbers to mean what they say.

- Smooth flow apart from the modelled crisis, a rigid ball, and no lateral wind shear along the flight.

## Limits

Where it is known to be wrong. Published because a model without stated limits is one nobody has pushed on.

- Near the crisis the real wake is unsteady, which is the knuckleball; a deterministic solver gives you the mean path and not the wobble.