Teacher's Key

The Physics of Football: Why Free Kicks Bend and Wobble (Level B2)

Vocabulary Matching

1 defy = **N**
2 fluke = **A**
3 swerve = **H**
4 spiral = **L**
5 pronounced = **G**
6 erratic = **M**
7 wobble = **I**
8 drag = **E**
9 abruptly = **D**
10 deceptive = **O**
11 grooves = **J**
12 trade-off = **K**
13 dense = **B**
14 anticipate = **C**
15 gamble = **F**

Fill in the Blank

1 defy
2 fluke
3 swerve
4 pronounced
5 erratic
6 wobble
7 drag
8 abruptly
9 deceptive
10 grooves
11 trade-off
12 dense
13 anticipate
14 gamble

True or False

1 **True.** The reading gives the distance as thirty-five meters.

2 **False.** It says many people assumed this. It does not say that everyone agreed, and the physicists later argued that it was not luck.

3 **True.** The sideways push is known as the Magnus effect.

4 **False.** They studied spinning balls in water.

5 **False.** The reading says that you might expect this, but it often does not happen.

6 **True.** There is no smooth curve to follow when the ball starts to wobble.

7 **True.** The reading describes it as a ball with only eight panels and a very smooth surface.

8 **False.** The rougher the surface, the lower the speed at which the switch happens.

9 **False.** It has four panels. The Jabulani had eight.

10 **True.** There is less drag in thin air, so passes and shots travel farther and faster.

Language Focus: Comparative Correlatives: The More..., the More...

Example answer: **The closer** the goalkeeper is to the ball, **the less** time he has to react.

Comprehension Questions: Model Answers

1 Roberto Carlos takes a free kick from about 35 meters and the ball seems to head wide before bending sharply into the net, while the goalkeeper stands still. Some people thought it was a fluke, meaning a lucky accident that nobody could repeat.

2 A spinning ball pulls the air around with it, and the air leaves the ball at different points on each side. This creates a sideways push (the Magnus effect), so the ball curves. The faster it spins, the more it curves.

3 They showed that as a spinning ball slows down, the sideways push matters more, so its path tightens into a spiral. On a long kick this becomes easier to see, and the researchers argued that the long distance was part of the secret of the goal.

4 A knuckleball is a kick with almost no spin. The air flows unevenly over the seams, so the sideways forces keep changing and the ball can drift, dip, or rise. Goalkeepers find it hard to read because there is no smooth curve to follow.

5 Drag is the air resistance that slows the ball. When the air around the ball switches from smooth to turbulent, the drag falls abruptly.

6 Golf balls show the same principle: a rougher surface makes the switch happen at a lower speed, which is why golf balls have dimples.

7 The Jabulani had only eight panels and a very smooth surface. Goalkeepers called its flight deceptive, and wind-tunnel tests suggested it lost speed faster than expected below a certain speed. Later balls have fewer panels than the old 32-panel design but more texture; the 2026 ball has four panels with deep grooves.

8 In thin air at altitude there is less drag, so passes and shots travel farther and faster, and spinning balls may bend a little differently. Visiting teams and goalkeepers have to adjust their judgment of the ball (and their breathing).

9 The ball can reach the goal in about four tenths of a second, but a goalkeeper needs about 0.6 seconds to reach either side. So keepers have to anticipate: they study the kicker's run-up and body, pick a side, and dive on a gamble.

10 Not Given. The reading says the free kick was taken with a run-up but says nothing about how often Roberto Carlos practiced such kicks.

11 No. The writer calls the wind-tunnel result “one set of tests, not a season of matches” and says players' own verdicts will matter too.

12 Best answer: to show how little time a goalkeeper has, which links all the physics in the reading (speed, spin, drag) to a real moment. The writer does not argue that penalties should change. Accept a reasoned answer.

Notes on the Evidence

- Source and approach: no source draft was supplied. The reading was written from the topic and every claim was checked by search in October 2026. The free kick: Brazil v France, Tournoi de France, Stade de Gerland, Lyon, June 3, 1997, from about 35 meters (Physics World and the Institute of Physics press release, September 2010); struck with the outside of the left foot (agency report, September 2010); the French goalkeeper stood still (BBC report, 2010). Reports of the ball's speed vary from about 130 to 137 km/h, so the reading gives no speed. The reading says only that he “takes a run-up”; accounts of its length vary.
- Spiral study: Dupeux, Le Goff, Quere, and Clanet, “The spinning ball spiral,” New Journal of Physics 12 (2010) 093004. Physics World describes experiments with light spheres tracked in water; some news reports say bullets were fired into water. The reading says “studied spinning balls in water”. The authors state that a long distance is a necessary condition for the spiral to appear, which supports “part of the secret”. The airflow explanation of the Magnus effect in paragraph 2 is simplified (air separates later on the side where the surface moves with the airflow).
- Knuckleball, drag, and the Jabulani: NPR (2010, opened) quotes physicists John Eric Goff and Rabindra Mehta on the 32-panel traditional ball, the eight-panel Jabulani, and knuckling. MIT Technology Review (June 8, 2026, opened) says goalkeepers described the Jabulani's trajectory as deceptive, explains the drag crisis, and quotes Goff on golf-ball dimples. Wind-tunnel work by Asai, Hong, Goff, and colleagues at the University of Tsukuba is the basis for the Jabulani claims. Sources differ on details: older reports say the Jabulani had less drag than earlier balls at high speed and more below roughly 45 mph; the reading says only that it lost speed faster than expected below a certain speed. “Once it slowed” is a plain-language version of the drag-crisis result.
- 2026 ball: Goff, Asai, Hong, and Liu, “Trionda: Enhanced Surface Roughness Relative to Previous FIFA World Cup Match Balls,” Applied Sciences 16(6), 2808 (2026), and the MIT Technology Review report on it. The four panels, three deep grooves per panel, higher drag at high speeds, and “a few meters shorter” long kicks (Goff's estimate) come from these. The result is from wind-tunnel data and simulation, not match data; the reading says “suggests” and “may”. Goff's affiliation is reported as Puget Sound or Purdue in different places, so the reading says only “researchers in Japan and the United States”. Claims about the ball's sensor and “AI” appear in many secondary sites and were left out as unverified or off-topic. Check for newer analysis of match data after the tournament.
- Altitude and penalties: Eniscuola (a school-education site sponsored by an energy company, June 12, 2026, opened) states that Mexico City is above 2,200 meters, La Paz about 3,600 meters, and that drag is weaker in thin air, so the ball travels farther and bends in slightly different ways. Other sources (Engineering Sport, 2010; a 2026 Asia Business Daily interview) say spinning balls bend less at altitude; the reading says “may bend a little differently”. Penalty timing: Cosmos Magazine says a powerful penalty can reach the goal in as little as 0.4 seconds, a goalkeeper needs about 0.6 seconds to reach either side, and about one second for the top corners. Estimates differ: a school maths essay computes 0.35 to 0.38 seconds at about 100 to 113 km/h; an older paper reports 0.4 to 1.2 seconds in real penalties. The distance of 11 meters is the 12-yard penalty mark (10.97 meters). Figures may be out of date.