The Physics of Football: Why Free Kicks Bend and Wobble

Name Date Class

Reading

1 Thirty-five meters from the goal, the Brazilian defender Roberto Carlos takes a run-up and strikes a free kick with the outside of his left foot. At first the ball seems to be heading wide. Then it bends, sharply and almost impossibly, back into the net, while the French goalkeeper stands motionless. That was Lyon in June 1997, and for years the goal looked as if it must **defy** the laws of physics. Many people assumed it was a **fluke**, a lucky accident that nobody could repeat.

2 The first part of the explanation is spin. When a ball spins, its surface pulls the air around with it, and the air leaves the ball at different points on each side. That creates a sideways push, known as the Magnus effect, and it makes the ball **swerve**. Hit a ball slightly off center and it starts to spin; the faster it spins, the more it curves. The second part arrived in 2010, when French physicists studied spinning balls in water. As a spinning ball slows down, the sideways push matters more and more, so its path tightens into a **spiral**, like the shell of a snail. On a short kick you barely notice this. On a long kick it becomes **pronounced**: the longer the flight, the more of the spiral you see. The researchers argued that the great distance was part of the secret.

3 Some of the most feared kicks do the opposite and carry almost no spin. You might expect a ball without spin to fly in a straight line, but it often does not. The air flows unevenly over the seams, so the sideways forces keep changing, and the ball can drift, dip, or rise in an **erratic** way. This is called the knuckleball effect. Goalkeepers often say that such a ball is impossible to read, because when it starts to **wobble** in mid-air there is no smooth curve to follow. To kick one, strike the ball through its center, so that it leaves your foot with very little spin.

4 Then there is **drag**, the air resistance that slows the ball down. It does not change smoothly with speed. At a certain point the air flowing around the ball switches from smooth to turbulent, and the drag falls **abruptly**. The rougher the surface, the lower the speed at which this switch happens, which is why golf balls have dimples. At the 2010 World Cup in South Africa, the Jabulani, a ball with only eight panels and a very smooth surface, caused an uproar. Goalkeepers described its flight as **deceptive**, and wind-tunnel tests suggested a reason: once it slowed below a certain speed, it lost speed faster than players expected.

5 Designers have learned from that criticism. Later balls have fewer panels than the classic 32-panel design, but more texture. The ball for the 2026 World Cup, made by Adidas, has just four panels, with deep **grooves** cut into each one. A wind-tunnel study by researchers in Japan and the United States suggests that the design behaves more steadily at lower speeds, but there is a **trade-off**: at high speeds it has more drag, so very long kicks may fall a few meters shorter. That is one set of tests, not a season of matches, so players' own verdicts will matter too.

6 Even the air matters. Mexico City, one of the host cities of the 2026 World Cup, lies about 2,200 meters above sea level, and La Paz, where Bolivia has long played many of its home games, is much higher still. At that height the air is less **dense**, so the ball meets less resistance. The thinner the air, the less drag: passes and shots travel farther and faster, and spinning balls may bend a little differently from what visiting goalkeepers expect. Visiting teams have to adjust both their breathing and their judgment of the ball.

7 Penalties show how little time anyone has to deal with all this. A hard shot from 11 meters can reach the goal line in around four tenths of a second, and researchers estimate that a goalkeeper needs about 0.6 seconds to reach either side of the goal at full stretch. Waiting to see where the ball goes is not an option. Keepers have to **anticipate**: they study the kicker's run-up and body, pick a side, and dive on a **gamble**. Even a correct guess is sometimes not enough, because a dive to the top corner can take a full second.

Vocabulary Matching

Match each word from the reading with its meaning. Write the letter on the line.

1	**defy**	_____	**A**	a lucky accident that is hard to repeat
2	**fluke**	_____	**B**	packed closely, with a lot in a small space
3	**swerve**	_____	**C**	to expect something and prepare for it early
4	**spiral**	_____	**D**	suddenly, with no warning
5	**pronounced**	_____	**E**	the air force that slows a moving object
6	**erratic**	_____	**F**	a risky choice with an uncertain result
7	**wobble**	_____	**G**	very clear and easy to notice
8	**drag**	_____	**H**	to change direction suddenly while moving
9	**abruptly**	_____	**I**	to move unsteadily from side to side
10	**deceptive**	_____	**J**	long narrow cuts or channels in a surface
11	**grooves**	_____	**K**	a balance where gaining one thing means losing another
12	**trade-off**	_____	**L**	a curve that winds around a central point
13	**dense**	_____	**M**	irregular, changing without any pattern
14	**anticipate**	_____	**N**	to seem to break a rule or a natural law
15	**gamble**	_____	**O**	likely to give a false impression

Fill in the Blank

Choose a word from the box to complete each sentence. Use each word once. The words are already in the correct form.

abruptly	**anticipate**	**deceptive**	**defy**	**dense**	**drag**	**erratic**	**fluke**	**gamble**	**grooves**	**pronounced**	**swerve**	**trade-off**	**wobble**

1 Some magic tricks seem to _____ the laws of nature.

2 Scoring from the halfway line was a lucky _____ , not a skill he could repeat.

3 A driver may have to _____ suddenly to miss a dog on the road.

4 After the move, the change in her accent was very _____ (starts with p).

5 The old printer behaves in an _____ way, printing some pages and skipping others.

6 If the table starts to _____ , put some paper under the short leg.

7 Cyclists bend low to reduce the _____ that slows them down in the air.

8 The meeting ended _____ when the power went out.

9 The photo is _____ : the mountain looks close, but it is two days away on foot.

10 Vinyl records have fine _____ that the needle follows.

11 There is always a _____ between price and quality.

12 Lead is a very _____ metal, so a small piece feels heavy.

13 Good goalkeepers try to _____ where the ball will go.

14 Putting all your savings into one company is a big _____ .

Comprehension Questions

Answer in your notebook or discuss with a partner. Questions 10 to 12 are IELTS-style.

1 What happens in the free kick described at the start of the reading, and why did some people call it a fluke?

2 How does spin make a ball curve, according to the reading?

3 What did the French physicists add to the explanation in 2010?

4 What is a knuckleball, and why do goalkeepers find it hard to read?

5 What is drag, and what happens to it when the air around a ball switches from smooth to turbulent?

6 Why does the writer mention golf balls?

7 What went wrong with the Jabulani at the 2010 World Cup, and how have designers responded?

8 How does altitude change the way a ball flies, and why might this matter for visiting teams?

9 Why can a goalkeeper not simply wait and watch the ball during a penalty, and what do keepers do instead?

IELTS-Style Questions

10 **True, False, or Not Given:** *"Roberto Carlos practiced long-range free kicks every week."* Explain your answer using evidence from the reading.

11 **Yes, No, or Not Given:** *"The writer believes that one wind-tunnel study can settle how the 2026 ball will perform."* Explain your answer using evidence from the reading.

12 **Author's purpose:** Why does the writer end with the example of a penalty kick? Is the aim to show how little time a goalkeeper has, to argue that penalties should change, or something else?

True or False

Circle T (true) or F (false) according to the reading. Write a correction for each false statement on the dotted line.

1 **T / F** Roberto Carlos took the free kick from about 35 meters away.

2 **T / F** The reading says that everyone agreed the goal was a lucky accident.

3 **T / F** The Magnus effect pushes a spinning ball sideways.

4 **T / F** The French physicists studied spinning balls in the air above a football pitch.

5 **T / F** A ball with almost no spin always flies in a perfectly straight line.

6 **T / F** Goalkeepers often say that a knuckleball is impossible to read.

7 **T / F** The Jabulani had a very smooth surface.

8 **T / F** A rougher ball switches to turbulent airflow at a higher speed.

9 **T / F** The 2026 World Cup ball has more panels than the Jabulani.

10 **T / F** Thinner air at altitude can make a ball travel farther.

Discussion Questions

Talk with a partner or in a small group. The questions move from personal to more abstract.

1. Do you play or watch football? If yes, what do you enjoy about it? If not, which sport do you prefer?
2. Have you ever tried to curve a ball in football or in another sport? What happened?
3. Which famous goal, shot, or kick, in any sport, do you remember best? What made it special?
4. Roberto Carlos's goal looked impossible, but physics explained it. Can you think of something else that seems like magic but has a scientific explanation?
5. Do you think a skilled player understands the physics of a kick, or does the body simply learn through practice? Why?
6. A goalkeeper has less than a second to react to a penalty. Which other jobs or sports demand very fast decisions, and how do people prepare for them?
7. Would you rather be the penalty taker or the goalkeeper in a shoot-out? Why?
8. Some players complained about the Jabulani, while others adapted. How do you react when a tool or piece of equipment you use suddenly changes?
9. Players at the 2026 World Cup had to play in cities at different altitudes. How can athletes prepare for conditions that are very different from home?
10. Is it fair that some teams play at high altitude all the time while others rarely do? Why or why not?
11. The reading says that one set of wind-tunnel tests is not the same as a season of matches. How much should we trust laboratory results about sport?
12. Data and measurement now shape many sports. Do you think more science makes sport fairer and more interesting, or does it take away some of the magic?
13. Football is played almost everywhere in the world. Why do you think one simple game with a ball appeals to people in so many different cultures?
14. If you could ask a physicist one question about a sport you love, what would it be?

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

A comparative correlative uses two comparative phrases, each beginning with the, to show that two things change together. When the first thing increases or decreases, the second changes with it.

In the reading:

- "...**the faster** it spins, **the more** it curves."
- "...**the longer** the flight, **the more** of the spiral you see."
- "**The rougher** the surface, **the lower** the speed at which this switch happens..."

Practice: Combine these two ideas into one sentence with a comparative correlative: *"A goalkeeper is closer to the ball. He has less time to react."*

Activities and speed challenge
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Notes