Name: _____ Date: _____

The Physics Inside 9.58 Seconds

Reading level 13 · 1855 words

At 21:35 on August 16, 2009, eight sprinters settled into the blocks at the Olympic Stadium in Berlin. The wind gauge would read +0.9 meters per second. In 9.58 seconds, one of them, Usain Bolt, would lower his own world record by 0.11 second, which World Athletics called the largest cut ever made to the 100-meter record. As of November 2026, the mark is still first on its all-time list. A world record is a measurement before it is a performance: a gun, a clock, a camera, a wind gauge and a rulebook decide what the number is. This book takes 9.58 apart, from the first thousandth of a second to the statistics that ask how much faster a human could run.

The clock starts with the gun. Under the rules, a fully automatic timing system must be started by the starter's signal with an overall delay of no more than 0.001 second. The finish is recorded by a camera in line with the finish line. Today's rules require at least 1,000 frames per second at top meets, with a time scale marked in hundredths, and a study of the 2003 to 2009 world championships says the official timekeeper's system captured up to 2,000 images per second. At Bolt's average speed of 10.4 meters per second, one frame at 1,000 per second is about one centimeter of running. A runner is placed when the torso reaches the line. Under the current rule, a time is rounded up to the next hundredth unless it is exact, so a recorded 9.58 stands for a true time between 9.571 and 9.580 seconds.

Reaction time is the interval between the gun and the first measurable push on the blocks. Bolt's was 0.146 second in the Berlin final. A study of 1,319 sprinters at the 2003 to 2009 world championships found that male finalists averaged 0.142 second in the final, and that reaction time shared 8.5 percent of its variance with 100-meter time: the start matters, but it is not the race. The rule sets a floor at 0.100 second, and anything quicker counts as a false start. That floor rests on an assumption about how fast the human ear and nervous system can act, and a 2007 study of nine athletes found five with mean reactions under 0.100 second in at least one condition. Whatever its physiology, the limit is enforced: since January 1, 2010, a false start disqualifies, as Bolt's disqualification from the 2011 world final in Daegu showed.

The official biomechanics report timed every runner every 20 meters. Bolt's times from the gun, which include his 0.146-second reaction, were 2.88, 4.64, 6.31, 7.92 and 9.58 seconds. The four sections between the 20-meter marks took 1.76, 1.67, 1.61 and 1.66 seconds. The report gives the same marks for each round Bolt ran, so his heat and semifinal can be set beside the final. World Athletics reported that he was not the quickest out of the blocks, and that he took control about 30 meters into the race. By this book's arithmetic, his 60-to-80-meter section averaged 12.4 meters per second, and his last section averaged 12.0.

The race is therefore a long acceleration, with the fastest section past the halfway mark.

Speed is the product of two quantities, step length and step rate. The same report counted 40.92 steps for Bolt's 100 meters and gave the average length and rate for each 20-meter section. In the first 20 meters, his steps averaged 1.78 meters at 3.89 per second. From 20 to 40 meters, his steps averaged 2.52 meters at 4.54 per second. From 60 to 80 meters, they averaged 2.77 meters at 4.49 per second. Multiplying gives 11.4 and 12.4 meters per second, which match the section times. In the last section, his steps reached 2.85 meters and his rate eased to 4.23 per second. From 20 meters to 80 meters his rate hardly changed. His speed rose because each step covered more ground.

A 2023 analysis used laser measurements of his position in Berlin. It found a highest velocity of 12.32 meters per second, about 44 kilometers per hour, at the 52-meter mark. It reports that he held that maximum across five 10-meter sections, from 50 meters to the finish. The steps taken with his left leg were longer than those with his right over almost 80 meters, which the authors call a functional asymmetry. The three speeds in this book differ a little: 12.32 from the laser, about 12.3 from a 2012 model of the same race, and 12.4 from the rounded section times. They come from different instruments and differ by about 0.1 meter per second. The sources also differ near the finish: the laser analysis has him holding his maximum to the finish, while the section times give 12.0 for the last 20 meters.

Why can a sprinter not simply swing the legs faster? Experiments suggest that the limit is force. In 2000, researchers had 33 people run at top speed on a force treadmill. Top speeds ran from 6.2 to 11.1 meters per second, and the fitted line said the faster end pushed on the ground 1.26 times as hard, while the time to swing a leg forward did not vary. In 2014, seven sprinters reached 10.4 meters per second against 8.7 for seven other athletes by applying more vertical force in the first half of each ground contact. A model of the Berlin race, not a force measurement, estimated his ground contact at 0.091 second per step at 60 to 80 meters. At 4.49 steps per second, each step lasts 0.223 second, so he was on the ground for about 41 percent of it.

A 2013 study compared three of his best runs: 9.69 in Beijing, 9.58 in Berlin and 9.63 in London. It found speeds above 12 meters per second, from 12.05 to 12.34, in some 10-meter sections of all three, and concluded that step length did most to set his speed in most sections. Its authors judged his height and leg length an advantage that is "not questionable," and suggested he was probably able to strike the ground more forcefully. Their tools were video and modeling, not force plates, so their claims are limited. Another 2013 paper modeled the Berlin run with a drag force that grows with speed and with speed squared, and fitted it to the laser data. Its authors say the model works only for short sprints. The studies describe what his body did. They cannot say how much of the result each factor supplied.

Wind is the one outside force the rules measure directly, so they fix exactly how it is read. For

the 100 meters, a gauge stands beside the track 50 meters from the finish and 1.22 meters off the ground. It measures from the flash of the gun for 10 seconds. A record cannot be ratified if the average wind in the running direction exceeds 2 meters per second. A 2016 study estimated that a 2-meter-per-second tailwind is worth about 0.10 second to a man, and that an altitude of 1,000 meters is worth about the same. Scaling that 0.10-second figure to Berlin's +0.9 gives about 0.04 second, so a no-wind equivalent of about 9.62 seconds by this simple scaling. That is an average for international sprinters, not a measurement of one race.

A record is not official when the clock stops. The meet must have been authorized in advance, and an individual event needs at least three athletes. For a sprint, starting blocks linked to a certified start system must have been used, so that reaction times appear in the results, and the wind must be within the limit. The national member sends the program, the full results and, for an automatic time, the photo-finish and zero-control images. On September 30, 2009, World Athletics announced that it had ratified Bolt's 9.58 (wind +0.9), which replaced his own 9.69 from Beijing on August 16, 2008, and his 19.19 in the 200 meters (wind -0.3).

The 200 meters, four days after the 100 in the same stadium, showed how much a start can vary. Another runner false started, and on that start Bolt's reaction was a slow 0.345 second. On the restart it was 0.133, the fastest in the field. He ran into a headwind and finished in 19.19, which was 0.11 second faster than his old record. Records in the 100 meters reach back to Donald Lippincott's 10.6 on July 6, 1912, and for decades they were hand timed in tenths of a second. Automatic timing has been required for ratification since 1977, which let the record be measured in hundredths. By 2012, World Athletics counted 44 men who had held or shared the record, with 67 ratified marks. Bolt set three of them: 9.72, 9.69 and 9.58.

Bolt won eight Olympic gold medals, as World Athletics and the International Olympic Committee count them through November 2026. He won the 100 and 200 meters at three Games in a row, in Beijing in 2008, London in 2012 and Rio in 2016, and the 4 by 100-meter relay in 2012 and 2016. The Olympic marks he set were 9.69 for the 100 in Beijing on August 16, 2008, and 19.30 for the 200 on August 20, 2008, both world records at the time. In London he ran 9.63 for the 100 on August 5, 2012, with a tailwind of +1.5 meters per second, inside the 2-meter limit. Olympedia still lists 9.63 and 19.30 as the Olympic records. World Athletics's profile also counts 11 world titles through November 2026.

Is there a limit? In 2008, a study fitted three statistical models to race data for greyhounds, thoroughbred horses and elite human runners. It concluded that each has an absolute speed limit definable from the data, and that the records are approaching it. A 2015 review of Olympic results from 1896 to 2012 reported a major slowing in improvement and said that further gains would depend mostly on sport technology and changes to the competition rules. In February 2025, two statisticians posted a preprint using data from 1991 through 2023. They estimated the ultimate men's 100-meter time at 9.56 seconds, with a 95 percent lower bound of 9.49, which they call quite close to the present record of 9.58. A preprint is a paper shared

before peer review. These figures are extrapolations from past results, not times anyone has run.

Bolt's last World Championships were in London in August 2017. At the end, he took a lap of honor, and the trackside clock flashed his Berlin times, 9.58 and 19.19. He stopped for a moment at the 100-meter start and at the 200-meter start. World Athletics quoted him: "I was saying goodbye to the fans and I was saying goodbye to my events also." Much of that night in Berlin has been measured: the gun, the reaction, the 41 steps, the wind, the frames at the line. The question that the statisticians pose remains open, because no one knows whether a human body can still give back the 0.02 second between 9.58 and the estimate of 9.56.

Questions

1. Why does the book say a recorded time of 9.58 stands for a true time between 9.571 and 9.580?

A. Timers disagree about exactly when the start happens
B. Under today's rules a time is rounded up to the next hundredth
C. The wind gauge slows the clock by a hundredth

2. According to the biomechanics report, how did Bolt's speed rise from 20 to 80 meters?

A. Mostly by faster steps
B. By taking fewer steps than before
C. Mostly by longer steps

3. In the sentence "The rule sets a floor at 0.100 second," what does floor mean?

A. A lowest allowed reaction time
B. The track surface
C. The stadium's lowest level

4. What did the 2000 treadmill experiment suggest limits top running speed?

A. The force applied to the ground
B. How fast the legs swing forward
C. The runner's height

5. Why are the studies of Bolt's stride described as limited?

A. They only measured the 200 meters in one race
B. Their tools were video and models, not force plates
C. They were written before the 2009 final was run

6. Why does the book call the 9.56-second figure an extrapolation?

A. It was measured on a track in a different country
B. It comes from a different race than the 100 meters
C. It is projected from past results, not run in a race

Words to know

ratified: officially approved
asymmetry: uneven sides
preprint: unreviewed paper
tailwind: helping wind
torso: upper body
extrapolations: projected estimates

Answer key: The Physics Inside 9.58 Seconds

1. B. Under today's rules a time is rounded up to the next hundredth
2. C. Mostly by longer steps
3. A. A lowest allowed reaction time
4. A. The force applied to the ground
5. B. Their tools were video and models, not force plates
6. C. It is projected from past results, not run in a race