

# The Physics of Baseball

By Hugh S. Fullerton

(Copyright, 1913, by W. G. Chapman)

The first law of physics is that all that goes up must come down; always excepting the cost of living. The first law of baseball is not to let it come down.

The difference between the physics of the classroom and of the diamond is that the student learns the laws governing inertia, velocity, dynamics, the curvilinear trajectory of projectiles, resisting power of air, attractive power of masses; and the ball-player, by experiment, deals only with the freak variants of these laws. Many times the student who makes his college team is apt to think that the prof. was stringing him when he laid down the laws of motion, mass and velocity. For a baseball under skilled manipulation and control seems, like a trust, to come as near violating all the laws as possible. The ball always is striving to do exactly what the laws of Physics say it should do, with half a dozen other forces striving to compel it to do something else, and with the bad boys in uniform trying to invent new methods of making it violate the law.

If the supreme court should find the law of gravitation unconstitutional, or if the ball player could breathe in an absolute vacuum, baseball would be a simple proposition. The ball would keep on going in a straight line until some one stopped it. Line hits would continue to travel in a straight line until some felder, standing on the needle point of infinity, jumped and pulled it down with one hand.

There is a professor of physics in a great eastern university who wrote me inquiring as to the physics of the spit ball, and who later lectured to his classes upon the subject. I asked several great pitchers to demonstrate for the benefit of the professor how they held the ball, swung their arms, released it with their fingers, and how much power they applied and to what point on the surface of the sphere. Among them was Clark Griffith, a master in theory, who used to be past-master in practice. I asked him to take the professor to the grounds and show him things. The result was a note from Griffith, in which he said:

"Don't send any more bugs to see me."

The point is that the players do not care what scientific phenomena they develop so long as the opposing batsmen take their healthies (i. e., swings) at the ball and miss. The college professor does not care much whether Walsh strikes Collins out three times with runners on bases so long as he can demonstrate that the laws governing rotation, air pressure, friction, retard and accelerated motion, etc., etc., are proved by the actions of the ball. So physics and baseball as studies have kept aloof from each other.

Yet every move in a ball game affords a problem. There are basic conditions which, in themselves, are worthy of study. Consider atmospheric pressure. Did you know that a man



Clarke Griffith.

who can throw a baseball 350 feet on the Polo grounds, New York, on a dead calm day, can throw the same ball almost 400 feet on the Denver ball park?

In studying the physics of baseball let us commence with the chief implements of the game—the bat and ball. The ball is composed of a small core, with a heavy layer of highly treated Para rubber, then wound with two kinds of woolen yarn, over which is a glue substance, upon which is a horsehide cover. The ball is semi-pneumatic, both the rubber and the glue upon which the cover is pasted tending to hold air. The difference even of a sixteenth of an inch in the thickness of the rubber makes the ball so fast that it scarcely can be handled. The makers experimented for years to get the ball tuned to the proper pitch of elasticity, and appear finally to have

accomplished the aim of making a ball not too "dead" and not too lively. The shock of the bat against the ball disperses the air gradually and at the same time causes a molecular change in the rubber so that a ball, after being batted hard, loses much of its resilient power. The disarranging of the molecular force causes a ball which, to an outsider may seem as firm and solid as ever, to become a "mush," dead and lifeless, and likely to slow the entire game if permitted to remain in play. The bats used are almost all of second growth ash of the finest and straightest grain, and carefully dried. They are supposed to retain their resilient qualities indefinitely, but after a month or two of hard usage the bat no longer possesses the "drive" necessary for hard hitting. Yet bats that have lost "life" often will, when kept in storage a few months, recover their lost "ring" and be as good as ever, although the second time they "die" more quickly. This sense of feeling and hearing among players is a wonderful thing.

The object of each batter is to "hit it on the trade mark" with that part of his bat between four and six inches from the end. He does not express it that way, but he aims to hit the center of mass of the ball with the center of percussion of the bat—so he says, "square on the nose." The center of percussion of the bat varies according to the grip of the batter's hands, and it is the object of the pitcher to force the ball to revolve so as to avoid meeting the center of percussion.

A ball weighing five and eight ounces and with a circumference of nine inches, pitched at an approximate velocity of 280 feet a second over a distance of 60 feet, is struck squarely upon the center of percussion of a bat weighing 40 ounces and swinging at a velocity of 1,250 feet per second, will travel how far? Perhaps the professor of physics can figure it out, but if he does he is wrong. He would have to know more than these statistics before he could make the correct calculation. He should know the forearm strength of the batter, the muscle leverage, the meeting angle of ball and bat, the rotary motion of the ball, the condition of the atmosphere, direction of wind and a few other things. It is much easier to have Vean Gregg shoot up a fast one, let Larry Lajoie hit it, and measure the distance, than to take a post-graduate course and calculate it.

Every ball that is pitched, or thrown, or batted has some rotary or oscillatory movement all its own further to complicate attempts to solve problems in baseball physics. The ball has a wonderful ability to absorb and retain motion no matter how imparted. The spit ball, which was so fully and exhaustively treated in the lectures of my friend the professor that I expect to see about 120 Walshes graduate from his school in the next two years, is the result of skillful applying of an unnatural force to counteract the natural rotation of the ball. The professor disputes this. Possibly he does not know that a ball, gripped with the thumb and two fingers, and thrown directly overhead, has a natural tendency to rotate upward and "hop," as the pitcher says. All good fast balls rotating this way take a sudden jump in the air. The spit ball pitcher wets the surface of the ball, grips the lower side tightly with his thumb, lets the ball slide off the fingers. The effect is that two conflicting forces cause the ball to "wobble" for a distance, and then, yielding to the influence of the thumb pressure and the attraction of gravity, it darts downward. When a ball thus pitched is hit it still refuses to surrender its inclination to rotate. It starts toward the infield with two forces still struggling for mastery. Each time the ball touches the earth it takes a different English. The infielder scoops the ball and throws. If he clutches the ball hard enough to kill all motion, all is well. If he seizes it lightly, and throws with the same motion the ball takes fresh and renewed English as it leaves his hand and is more likely to shoot out of reach of the batsman toward whom he throws.

The pitched ball, manipulated so as to revolve unnaturally, takes "English" in the air just as a billiard ball does against cloth and cushion. Many persons have told me that the atmosphere on a still day offers practically a uniform resistance to a projectile. It does not. We know now that the air is filled with eddies, currents and pockets, even on the calmest of days. But admitting that it is uniform in density, a ball does not follow the physical law of constant decrease in speed in ratio to the resistance of the air. It even is capable of accelerated motion, and of both in the same 60 feet. That is, a ball may be made to slow up and then resume a faster rate of speed. The professor of physics doubts this, yet it is a fact that any experienced ball player will vouch for. They have seen a ball seem to hesitate, and then proceed at an accelerated gait. It may sound impossible but at some spot in the path of every spit ball, slow ball or knuckle ball, it suddenly changes pace.

We experimented once with a pneumatic gun the rifling in the barrel of which gave it heavy rotation in any desired direction. It was merely an exaggeration of the curve. We shot balls under 30 pounds of pressure, making them curve sometimes a hundred feet. Putting the up curve motion on the ball (which always tends to curve in the direction of its rotation), we aimed the gun at a target exactly on a straight line, and the ball, going straight for perhaps a hundred feet, suddenly seemed to slacken speed, then it leaped upward and rose at a terrific rate until it passed over the cross bar of the flag-pole in the center field, 70 feet above the ground. Yet the ball was not disobeying the laws of physics, rather proving them. In its terrific speed it had encountered an air billow which it could not penetrate, and it had bounced off this denser bunch of air and rolled upward.

One would think that if a baseball is hit into the air it will follow a ballistic curve in ratio to the angle of ascension reduced by the amount of air pressure. Physics says it should. It will not, and no man can draw the ballistic curve that any fly ball will follow. The greatest range of any projectile in theory, is gained by an angle of 45 degrees. Military authorities know that, owing to air resistance, the greatest distance is attained at an angle just under 40 degrees. Having both the theory and the practice, therefore, ball players to make home runs should hit the ball at an angle of 40 degrees minus. One of



John Kling.

Frank Baker's world's series home runs was near that angle, the other scarcely 30 degrees, it went farther. As a matter of fact, even if a ball-player could hit a ball at any desired angle, he could not be certain where it would go. It would depend too much upon the rotary motion of the ball. Last summer I saw a hard line hit driven straight at Charlie Herzog of the Giants. He put up his hands to catch the ball, then suddenly threw his head aside just in time to avoid being hit in the face, the ball missing his hands by two feet. The ball had "shot" suddenly from its true path.

In a game between Washington and Chicago late last fall, Walter Johnson hit a ball at an angle of close to 40 degrees, and with terrific force. I should estimate that it was nearly 90 feet high, at its greatest elevation. Had it followed the true ballistic curve, it would have passed over the center field fence. The ball suddenly stopped, started to drop straight downward, then caught in another current of air, and Bodie, who was running after the ball, overtook it coming toward him, as if the batter had hit it from center field. Under conditions such as these a study of aerodynamics would help players more than physics would.

The outfielder who "gets the jump" on the ball at the crack of the bat figures its trajectory at a glance, sprints desperately outward and turns exactly upon the spot where the ball will alight, then catches it, has all the calculations ever devised beaten.

Physics assumes that balls, thrown with equal force, following the same angle of projection over the same range, will be alike. I never doubted it until I practiced at second base with Malachi Kittridge and the lamented Tim Donohue throwing the ball down to me. Donohue threw faster, and seemed harder, yet the ball came into the hands as lightly as if tossed. Kittridge's thrown ball came more slowly, but it jarred and bruised the hands. This peculiarity of throwers is understood well by players, and one of the first inquiries concerning a new player is whether he throws a light or a heavy ball, which refers to the striking force of the ball, and not its weight. A ball revolving naturally, and thrown over the finger tips, as a fast ball is thrown, has a tendency to lift in light. One that loses its rotary motion, and oscillates rather than rotates, is "dead" and heavy. Every player throws a different kind of ball, the variations depending upon the size of the hands, the length of the fingers and the manner of holding the ball.

The man who knew enough about physics, and also about baseball, could fill a book on the physics of pitching. It is simple, while seeming complex. It was not so very long ago that Tyns, the Harvard pitcher, developed a curve ball that started a protracted argument which finally resulted in a group of learned professors gathering to decide whether a ball actually could be made to curve in the air. The professors who doubted the possibility of a ball curving based their doubts upon the alleged insufficiency of air resistance. They admitted the

theory, and doubted the fact. Every curve, shoot, "hook," "fadeaway," and slow ball depends upon the same principles, revolution and air pressure. The way a ball curves depends upon the force with which it is thrown and the amount of rotation. Its direction depends upon the amount of friction applied by the fingers to a given point on the surface of the ball. The ball always curves in the direction of the heaviest friction applied by the hand, and away from the heaviest air friction. The curve increases in the ratio of the amount of its revolution.

Perhaps the most frequent question asked of a baseball writer is, "How far can a ball be made to curve?" Of course they mean by a normal pitcher not using mechanical assistance. I never have been able to find the limit of the curve, nor, indeed, to calculate the curve accurately, although I have made some experiments. I refer to the actual curve of the ball due to its rotary motion and air resistance. I do not think that the real curve of the ball in 56 feet (distance from the pitcher's hand when he releases the ball, to the home plate) can be more than 20 inches. I have heard ball-players declare the ball curves from six inches to five feet. I tried it once with Orval Overall, who had, I believe, the most sweeping and widest fast curve ball I ever saw.

We placed 12 big sheets of tissue paper between slats, 8 of them at short intervals over the first 15 feet in front of the plate, the rest scattered at wider intervals until the last one was 6 feet in front of the pitcher's slab, and, to my surprise, his hand struck the paper as the ball was released, proving the actual distance—of the pitch is much shorter than usually supposed. Of course Overall's reach was much greater than the average, but I do not think the actual pitching distance, from hand to plate, is more than 56 feet.

Overall pitched his wide overhand curve. The ball entered the first sheet four feet to the right of the center of the two plates at a height of five feet, and almost six feet above the ground (he was pitching off a slight elevation). His hand hit the paper and tore a hole a foot lower, showing he had released the ball before his arm reached the extreme limit of its swing. The ball went through the second sheet, which was 10 feet from the first just four inches lower than through the first, and a little over two and a half feet from the right of the line. It was less than a foot from the line when it struck the first of the eight sheets placed closely together in front of the plate, and it tore through the next one a trifle higher. Then it began its true curve. Nine feet in front of the plate it "broke" and shot downward and outward and crossed the sheet at the home plate ten inches above the ground and nearly twelve inches to the "outside" (that is, for a right-handed batter) of the center of the plate. The ball had dropped five feet two inches downward, through the force of gravity, the angle at which it was pitched and the curve, and had angled and curved practically five feet. The closest calculation we could make was that the ball actually curved, as a result of its rotary motion, approximately 17 inches.

The air resistance, which was disputed at Tyns' experiments, has, of course, become a known factor with the study of the science of aeronautics. The amount of resistance can be computed closely by the use of the barometer. The ball curves in the direction in which it revolves. The amount of the curve depends upon the



Christy Mathewson.

rate of rotation and the weight of air. The entire science of pitching consists in the deft application of friction upon some point of the ball which makes it rotate in a certain direction, or which counteracts its natural rotation and cause it to "wobble" or float with little revolving motion. The slow balls, fadeaways, knuckle balls, all have as their object the prevention of rotary motion, or to give false rotary motion of "reverse English." The ball that presents the most air surface to the resistance of the atmosphere slows up quickest and yields more rapidly to gravitation. The one that spins oftenest (not necessarily fastest) curves most.

## CAMP FIRE STORIES

### STIRRING SIGHT ON POTOMAC

Pen Picture by Private of Dull Days Before Early Woke Up Washington in July, 1864.

Some time in June, 1864, we came up from New Orleans, and went into a fort on a hill back of Alexandria, Va. There is a low range of hills there that extends up and down, overlooking the Potomac river. On this elevation a chain of forts had been built some time before, about two miles or so apart, but at this time there were only a few soldiers in them. For some miles toward Manassas the country is rolling, with here and there a deep ravine and fine woodlands and nice streams of water.

Alexandria was an old, sleepy town, the wheels of progress were stopped, and one would think the war was over to see the farmers coming in with their butter and eggs to exchange for goods. There is a valley and quite a large brook running through it that empties into the river on one side of the town. A little way up was an old gristmill with a large overshot wheel, writes Oscar Pelton, of Portland, Ore., in the National Tribune. Some blockhouses were being built along the roads going up the valley. Over in Washington everything was quiet. The sidewalks would be crowded some days with one-legged and one-armed soldiers hobbling along with a sprinkling of officers and men with tanned faces and shabby uniforms that would tell you at a glance that they had seen hard service at the front. Everyone felt safe, no danger, and many were going to the theater and having a good time. It was the calm before the storm.

On July 1 we had been drilling on the big guns and having target practice for some days. At night a great squad would be sent out over different roads leading out of Alexandria, and men were sent with dispatches at midnight from one fort to the other all along Arlington Heights.

It was thought that Mosby might make us a visit. I think it was about July 10 or 11. A lot of us had been out on the road leading back toward Manassas all night and were coming in in the morning. It was very hot weather. We got in the fort at 9 or 10 a. m. We had coffee and a lunch. It was so hot that a few of us went out under some trees. We had a fine view of the river for ten miles.

"What's up?" we asked. "There isn't a boat to be seen on the river this morning." We all looked. "It never has been that way since we have been here."

Below Alexandria the river bends around, so boats coming up would seem to come out from behind the timber to us. As we were sitting under the trees later we happened to look down, and saw a great fleet of transports coming out from behind the timber.

It was no time before they were nearly up to Alexandria, and still they kept coming out from behind the timber. We all jumped to our feet, and one said: "What's up?"

All the garrison came out to watch. It seemed that every boat was trying to see which would reach Washington first. They were now passing Alexandria. We would see by the foam dashing out from behind the great sidewheel transports that every pound of steam was crowded on. The last boats were passing us, and they filled up the river for nearly ten miles, and their decks were crowded with soldiers. The music struck up on some of the transports, and there never will be such a grand sight on the old Potomac again. A dispatch bearer came to the fort, and reported that there was a large Confederate army before Washington, and 40,000 were being brought from the Army of the Potomac to reinforce the forts north of the city.

We had heard cannonading, but thought it target practice, but the old private was not supposed to know anything, anyway.

#### On Quarterdeck of Mule.

On the capture of Morris Island the whole mass of men was thoroughly pervaded by that feeling of hilarity that follows a quickly successful engagement—soldiers and sailors shouting, singing, happy.

A bronzed blujacket had captured a mule, and without difficulty mounted it. He perched himself near the animal's tail, the mule objecting in every known way of a mule and in some ways until then unexhibited.

"Jack, sit more amidships," said Hardy, the first engineer of the Weehawken, "and you will ride easier." "Captain, this is the first craft I was ever in command of," said he, "and it is a pity if I can't stay on the quarterdeck."

#### Bees and All.

While the Army of the Cumberland was on the march from Bridgeport, Ala., to Louisville, Ky., one brigade was commanded by Colonel Willich of the Thirty-second Indiana. He had been an officer in the German army. One day a planter came to camp and complained that the boys had taken all of his honey. The colonel asked him if the boys had taken his bees.

"Oh, no," said he. "Oh, vell," said the colonel, "dot is nothings den; in de old country ve take pees and all."

Entertaining Literature.  
"I wish I had a fairy tale to read."  
"Here's the seed catalogue."

Mrs. Winslow's soothing Syrup for Children, soothing, softens the gums, reduces inflammation, allays pain, cures wind colic, etc. in a bottle.

Taking the whole of Europe into consideration, there are 107 inhabitants to the square mile.

ASK FOR ALLEN'S FOOT-EASE, the Antiseptic powder to shake into your shoes. Relieves Corns, Bunions, Ingrowing Nails, Swollen and Sore feet, Blisters and Callous spots. Sold everywhere. Ho, Don't accept any substitute. Sample FREE. Address Allen S. Oimsted, Lefroy, N.Y. Adv.

Just as Likely to Learn.  
"May I ask you how old your wife is?"  
"Certainly; you may ask her, too, if you wish."

Her Interest.  
"Your mother asked me if I smoked cigarettes. Does she disapprove?"  
"Not at all. She's saving coupons," said the fiancee.

Foolish Self-Condensation.  
No comfort for the living or the dead can be won from vain self-condemnation. No consolation can be gained while you nurse the imagining that a certain trouble might have been avoided. What we have to do is to try to escape from other troubles that are truly avoidable—troubles of a useless remorse, a present neglect, a listless apathy that will not reach forth for the good things still to be gathered.—Exchange.

Remains of Old Civilization.  
Scattered throughout the Caroline Islands, notably at Ponapee and Lelo, are massive ruins, one of a sort of Venice, whose origin is wrapped in mystery. Hundreds of acres in some localities are covered by the remains of walls, canals and earthwork of a stupendous character. There are old roads paved with stone blocks, ancient stone platforms, and on the lagoons ruins of what were once flash weirs. The islands offer a rich field for the archaeologist.

The Lesser of Two Evils.  
A gentleman from the north was enjoying the excitement of a bear hunt down in Mississippi. The bear was surrounded in a small cane thicket. The dogs could not get the bear out and the planter who was at the head of the hunt called to one of the negroes:  
"Sam, go in there and get the bear out."  
The negro hesitated for a moment and then plunged into the cane. A few moments after the negro, the bear and the dogs were rolling upon the ground outside.

After the hunt was over the visitor said to the negro:  
"Were you not afraid to go into that thicket with that bear?"  
"Cap'n," replied the negro. "It was jest dis war. I nebbor had met dat bar, but I was pusuonally 'quainted wid old boss, and I jes' naturally tuck dat bar."  
"Vacillating."  
At a dinner not long ago Thomas W. Lawson was talking on the subject of success.

"Success in finance," said Lawson, "is due in a great measure to prompt action. The doubting, hesitating, Hamlet type of men had best keep out of finance. He is quite sure to be swamped. The street hasn't much use for him. I had a boyhood friend of this type named Grimes. He was a falterer, a doubter, a Hamlet of the most exaggerated type.

"One evening I stopped to call on him and found him in a deep study, bent over a white waistcoat, lying on a table.

"Hello, Grimes," I said. "What's the matter?"  
"This waistcoat," he replied, holding the garment up to my view, is too dirty to wear, and not dirty enough to send to the laundry. I don't know what to do about it."—Everybody's.

MEMORY IMPROVED.  
Since Leaving Off Coffee.

Many persons suffer from poor memory who never suspect coffee has anything to do with it.  
The drug—caffeine—in coffee, acts injuriously on the nerves and heart, causing imperfect circulation, too much blood in the brain at one time, too little in another part. This often causes a dullness which makes a good memory nearly impossible.

"I am nearly seventy years old and did not know that coffee was the cause of the stomach and heart trouble I suffered from for many years, until about four years ago," writes a Kansas woman.

"A kind neighbor induced me to quit coffee and try Postum. I had been suffering severely and was greatly reduced in flesh. After using Postum a little while I found myself improving. My heart beats become regular and now I seldom ever notice any symptoms of my old stomach trouble at all. My nerves are steady and my memory decidedly better than while I was using coffee." "I like the taste of Postum fully as well as coffee."

Name given by Postum Co., Battle Creek, Mich. Write for booklet, "The Road to Wellville."

Postum comes in two forms.  
Regular (must be boiled).

Instant Postum doesn't require boiling but is prepared instantly by stirring a level teaspoonful in an ordinary cup of hot water, which makes it right for most persons.

A big cup requires more and some people who like strong things put in a heaping spoonful and temper it with a large supply of cream.

Experiment until you know the amount that pleases your palate and have it served that way in the future. "There's a Reason" for Postum.