Tranzmitted Side

Sidespin on the *q*ball ken ***throw*** the yellow & red to one side, & sidespin ken also ***tranzmit*** side-spin to the yellow & red. I say ken, koz what we might call ***natural sidespin*** remoovz any ***horizontal*** friktion between the ballz, & hence rezults in zero throw & zero tranzmitted spin --- horizontally speaking. In fact, if the *q*ball haz zero spin, ie pure rolling (ie pure topspin, & pure backspin), it allwayz puts som sidespin on the object-ball, & allwayz rezults in som throw. Sidespin & tranzmitted side & throw are, or kenbe, critical to the play of nurseryz. In this chapter i uzually ignore the vertical component of throw, & the non-sidespin component of the tranzmitted rotation. If there woz no ***horizontal friktion*** between the ballz, the object-ball would depart on the line joining the centerz at impakt. But horizontal friktion, ie throw, givz the object-ball a different line. Here, when i talk about ***the line*** joining the centerz at impakt, i ignore the fact that there iz no such line, or in other wordz, there are an infinite number of linez --- koz impakt involvz time & distance --- the line at ***first contact*** iz different to the line at ***last contact*** --- the ballz hav temporary ***flatspots***. Hmmmmmm. Billiardz Arithmetically Treated looks into all of this stuff in great detail. Suprizingly, there haz been ***much argument*** over a long period of time regarding the xistence of tranzmitted side --- tonz haz been written on this subject --- basically, almost everyone woz ***wrong***.

Keith Simpson The Billiard Player Nov 1950

.....Willie Smith when writing about transmitted side is both right & wrong. He is right when he says one can't play nursery cannons without what he calls transmitted side.

..... If left-hand-side is used.....the object-ball is given a turn to the right. Spin is not imparted to it..... When i use the word turn I do not mean spin, i am referring to direction only.

Comments

Simpson is partly wrong --- U karnt hav throw without tranzmitted side.

Willie Smith Som, playerz, like Willie, beleevd in tranzmitted side but attributed the whole of any such effect to tranzmitted side, not understanding that most of the effect in som casez woz due to throw. Hmmmmm.

Keith Simpson Som beleevd in throw, but not in tranzmitted side.

Riso Levi Som dummkopfs, like Riso, did not beleev in tranzmitted side nor throw. They were totally devoted to the zerospinizm religion. Or at best they beleeved that tranzmitted side woz very insignificant. Actually, Ivory Ballz were a bit more slippery than Bonzolinez or Crystalates, so perhaps we shouldn't be too critical of the real old-timerz.

Fred Lindrum One, Fred Lindrum, had brainz. On the other hand, Fred converted to ***zerospinizm*** in later yearz. This iz a strange one --- he began to follow false prophets & pray to false godz --- he forgot hiz own true epistle, in hiz own book. Hmmmmmmm.

Fred Lindrum

Spot End Billiards
Technique and First Principles 1913

Dolly sed that Fred woz very studyus & well read --- this xcerpt proovz it.

In professional billiards, particularly at the top of the table play, the transmission of side from the cue ball to the object ball is always taken into consideration. In a given screw cannon, for instance, it might be possible to score without any side; yet the after position and the continuation of the break might depend on the angle at which the object ball came off the cushion. The angle is modified by the side.

Apart from this effect of side, there is a modification also in the direction taken by the object ball. The ball is not merely driven forward, but it is ***flicked*** *slightly to the right or left, according to the direction in which the cueball is spinning. These delicate effects are usually ignored by amateurs, but they will repay study. In top of the table play especially it is often essential to make use of* ***transmitted*** *side to keep the balls at the spot end.*

But first 'catch your hare,' which in this case means first prove that side can be transmitted from one ball to the other, and also that the direction of the object ball will also be affected after contact with a spinning cueball.

The transmission of side can be easily shown. Place the balls on the baulk line, and about 7 inches or so apart. Using as much left hand side as possible (but it is not necessary to strike hard), make a nearly full contact with the red, so as to ***drive*** *it just out of baulk. (Fig. 1.) If this is done properly the red will always come back into baulk, though its natural direction if course would be to come off the cushion and travel still further from the baulk line. Now try the same shot with right-hand side, and it will be seen that the reverse effect is produced.....*

But those who are willing to admit the possibility of side transmission are more ***doubtful*** *when it comes to the alteration of the direction of the object ball after contact.....*

A method of testing the ***deflection*** *theory is to place a cue, with the butt against the side cushion and the tip under the bottom cushion. (This is just to keep it steady.) The cue must be on the left-hand side of the table, as few people possess the power of spinning a ball between the fingers from right to left. Place red ball against the butt of the cue, and then spin the white down the cue (which simply acts as a guide) on to the red.*

If the white hugs the cue all along as it spins (as it can be made to do with a little practice), it is obvious that the contact between the two balls must be exactly full. If, then, there were no deflecting effect, the red would be driven straight ahead, still touching the cue. But this will not happen. The red will always be deflected outwards—that is, to the right.....

Flick Tests Uzing Fingerspin

Anyhow, I did me own tests, for Billiardz Arithmetically Treated --- here are som snippets etc.

Fred uzed the term ***flick***. Nowadayz it iz uzually called ***throw***. But I will uze ***flick***, koz Fred iz one of my heroez. Don't worry if theze snippetts hav poor or nil continuity, no one understandz this stuff anyhow.

My tests showed that the ***red*** woz ***flicked*** 30mm when ***driven*** 600mm, which givz a ***deflection angle*** of 1 in 20 --- or 5% --- or 2.86°.

This showz that the ball to ball friktion force (acting tangentially) iz 5% of the ball to ball impakt force (acting on the line of the centerz). So, the coefficient of kinetic friktion iz 0.05. The coefficient of static friktion would be say 0.07 (just guessing).

Obviously the coefficient of kinetic friktion would depend on the materialz uzed to make the ball, ie ivory, phenolic rezin, etc. Or, more correctly, the material on the surfacez of the ballz, az I think that the modern krapball often haz a specially formulated or treated surface.

Flick Tests Uzing Qball

The above tests were done uzing lots of fingerspin, and I couldn't be sure that they were realistic, ie that they could occur in actual play. So I carryd out som further tests uzing a cue. I put the ***white*** against the ***red***, uzing a straight length of timber to make sure they were aligned at a target point on the far cushion. I cued a third ball into the ***white***, hard, at varyus anglez, and with varyus amounts of sidespin on the **qball**, and I mezured where the ***red*** hit the cushion.

The ***flick*** woz somtimez 75mm in 1500mm, which iz xactly 1 in 20. For som tests I put varyus foreign substancez between the ***white*** and ***red***, ie a little ***chalk*** or lots of chalk, and theze gave a ***flick*** of up to 305mm. ***Saliva*** gave 20mm. A ***hair*** gave 30mm. Uzing chalk, and hitting hard, uzually created a ***scuffmark*** on the ***red*** (which somtimez could only be remoovd with lots of ***polishing***). When this scuffmark woz placed against the ***white***, the ***flick*** woz 134mm.

Theze tests showed that the ***fingerspin*** rezults were not unrealistic, and could be xpected in actual play, ie uzing a ***cue***. A few timez, I hit the ***white*** directly with the cue, ie I did not uze the third ball. When I hit the ***white*** with the cue, I could make the ***red flick*** up to 107mm.

Which remindz me that we recently had to stop a match, to replace one of our sets of billiardz ballz, koz the ***red*** woz badly scuffed, and the rezulting number of ***kicks*** woz farcical. Obviously, somone had been hitting the ballz very hard in praktis, probably practicing screw shots, and hence woz uzing lots of chalk, but he had not bothered to keep the ballz clean. Also, he had probably uzed the ***red*** az a Qball, to save time. Anyhow, scuffmarks will polish out naturally in time. I reckon that there are ***3 types of scuff marks.....***

.....(***i***)..*q*tip--*q*ball.....(***ii***) *q*ball--2nd Ball (impakt).....(***iii***) *q*ball--2nd Ball (impakt plus kick).

Tranzmitted Side

Ok, we know about the flick and deflection angle, but how much tranzmitted side iz there ??

There iz a fixed relationship between the ***flick*** and the ***tranzmitted side*** --- i meen mathematically the friktion force giving one unit of ***flick*** will giv ## units of ***tranzmitted side*** there iz a simple equation linking the two --- applying to all solid spherez. It would be different for other shapes, ie for solid cylinderz, hollow tubez etc. I hav allwayz been amazed that the educated professionalz and amateur scientists of old did not realize this --- & i fear that few modernz hav bothered to do the maths. Anyhow, I'm not going to wait any longer, here it iz.

$$V_{rps} = {}^{2}/_{5}\,\omega_{rps} \qquad \text{or} \qquad \omega_{rps} = 2\tfrac{1}{2}\,V_{rps} \quad \textbf{.....(1)}$$

The tranzmitted sidespin (ω_{rps}) mezured in revz / sec, iz 2½ timez the ***flick*** (V_{rps}),.

This answerz our earlyr *qu*estion --- it tellz us that one unit of ***flick***, ie 1.0 rps, will yeeld 2.5 rps of ***tranzmitted side*** --- this applyz to all solid spherez, ie all makes of ball. It's a surprizing rezult. You would think that one unit of ***flick*** (rps) would giv one unit of ***tranzmitted side*** (rps), or even a lot less. But the 1 : 2½ ratio iz a fixed relationship that applyz to all solid spherez. It meenz that 1 rps of linear momentum iz equivalent to 2½ rps of rotational momentum (which I guess we knew allready) --- but this duzn't really tell us a lot ---- we kendo more.

So, from (4) and (5) $\omega_{rps} = 2\tfrac{1}{2}\,\mu\,V_{rpsdrive}$ .... ***...(2)*** for all solid spherez.

For our red, μ = 1/20th so ω_{rps} = 1/8th $V_{rpsdrive}$ ***...(3)*** for my red only.

Note that I don't meen that the ***red*** iz rolling at som number of rps --- i meen that the ***red'z*** actual straight line velocity (m/s) iz xpressed az rps --- rolling or not. It just makes thingz eezyr to talk about, koz I prefer to describe the ***tranzmitted side*** in rps. Anyhow, m/s or rps, it makes no difference to theze equationz.

Equation (6) iz the one we were looking for. It applyz to all solid spherez. It givz you the maximum possible ***tranzmitted side*** rezulting from a ball to ball impakt. It's interesting but of course you karnt uze it for anything practical ---- anyhow who knowz what μ iz for their ballz. All of this type of analysis iz for interest only --- but then again if it helps you to be aware of thingz that ken happen on the billiard table, then it iz more than just interesting I think.

Equation (7) iz actually more interesting. Koz I calculated μ i ken now say that the maximum possible ***tranzmitted side*** on my ***red*** (rps or m/s), iz 1/8th of the ***drive*** velocity (rps or m/s) of the ***red***. This ratio should apply to any other Super Aramith ball, not just the American or Continental size ball (63mm) that I uzed for my ***flick*** tests. I guess that the surfacez of other ballz might not alwayz be identical, ie μ would vary som, even if they were the same make ---- I meen that the radius won't make any difference to the equation. I cheated a little in the ***flick*** tests, koz I uzed the very large 63mm Super Aramith ballz ---- theze were much eezyr to test (more consistent and more accurate) than my small 52.5mm Super Aramith ballz.

By the way, equationz (4), (5) and (6) do not need the uzual qualification that iz needed in almost every other such analysis –- I meen we don't hav to say *"**if there are no energy lossez at impakt***. Theze equationz are perfikt just the way they are, koz the ***flick*** woz mezured, ie it's not theoretical. Theoretical thingz often need that sort of apology.

Example

A hard hit will send a Qball (white) sailing off at say 6.6 m/s, which would be equivalent to a speed of 40 rps (the radius of an English billiard ball iz 0.02625m, and the circumference iz 0.16493m). Say that this white haz oodlez of sidespin, and it iz skidding with zero or very little topspin, and it hits a stationary red ball --- full ball. If the Koefficient of Impakt iz 1.00 (it iz probably only 0.90), it will drive the red at 6.6 m/s (or 40 rps). And, if μ = 1/20th, it will flick the red at 0.33 m/s (or 2 rps). The deflection angle of the red would be 1 in 20, or 5%.

The deflection angle iz μ for all speedz (here we additionally ignore the fact that the Koefficient of Impakt varyz with speed), if there iz enuff sidespin on the white, and if there izn't too much topspin (topspin would rob som of the horizontal friktion). Perhaps I should hav sed that the deflection angle iz never more than μ.

And, if μ = 1/20, then the white will tranzmit side to the red equivalent to 1/8th of 6.6 m/s (ie 1/8th of 40 rps). So, the red will receive a sidespin of 0.825 m/s (ie 5 rps). And the white will looz the same amount (if we ignore the ball-to-ball skidding energy lossez). Simple az that.

When it hits the red, the white will looz all that it givz the red. It loozez 40 rps of velocity, and it loozez 5 rps of sidespin. But it duz gain somthing. It will flick in the opposite direction to the red, ie at 2 rps. Of course, if there iz a little pre-existing topspin on the white, then this will shortly cauze the white to continue on a little.

The abov speedz are just after impakt --- i don't take into account any ball to bed skidding lossez or rolling lossez that a ball sufferz (or enjoyz) befor it iz happyly rolling along.

Insufficient Spin

If the above white haz insufficient sidespin before it hits the red, then in relation to tranzmitted side, the best that it ken do iz to giv the red half its sidespin, while retaining half (actually a little less than half in each case, az there will be additional lossez). And the deflection angle would allso be smaller (than 1 in 20), in the proportion tranzmitted side / maximum possible tranzmitted side.

When there iz more than enuff spin on the white, there will be slippage between the white and red all throo the impakt event. And, after impakt the white will hav more spin than the red. But, if the white haz insufficient spin before impakt, slippage will cease somtime during impakt, and the white and red will end up with equal (but opposite) spinz.

TopSpin

If a *q*ball haz lots of sidespin and lots of topspin before it hits the red, then there will be less tranzmitted side. The friktion forcez and the tranzmitted spinz in varyus xamplez might be the same size --- but the rubbing contact between the ballz might not be in the same direction. In our xample the rubbing contact woz horizontal (or very nearly) --- if the rubbing contact woz largely vertical, the friktion force would hav a large vertical component. Therefore, the horizontal component of the friktion force would be less, and, therefore, the tranzmitted side would be less (in proportion). This iz partly due to my convention, or Fred'z convention really. He assumed that

tranzmitted side iz the horizontal component of the ball'z rotation. Anyhow, it kind'ev makes this article simpler, koz flick iz basically horizontal also.

Az i didn't xplain earlyr, if there iz a little topspin i suspekt that the red'z deflection angle could possibly be increased a tiny bit due to masse' (ie it could be more than 1 in 20), but lots of topspin would reduce the deflection angle , ie it would be a little less than 1 in 20, or a lot less. Hmmmm.

Leslie Kidner'z Tests

I woz interested to read the March 1951 edition of ***The Billiard Player***. Leslie Kidner, a Civil and Structural Engineer, and a top amateur billiardz player, wrote that .....

> *My experiments showed that under the most favourable conditions, the amount of side tranzmitted from the cue-ball to the object ball does not exceed 12% and in general is much less than this, and, therefore, difficult to detect by direct observation during a game.*

We hav a problem here. By my reckoning, the amount of *tranzmitted side* is alwayz in the range 0% to 50%, not Leslie'z 0% to 12%.

I meen, if the white hits the red (full ball) with a velocity of say 1 rps (which would be 0.165 m/s), then Equation (7) tellz us that it ken giv the red up to 1/8th of 1rps of side, ie up to 1/8thrps. So, if this white woz spinning at say.....

10 rps	it might giv the red 1/8thrps,	ie1/80th of its side (1.25%).
1 rps	it might giv the red 1/8thrps,	ie 1/8th of its side (12.5%).
¼thrps	it might giv the red 1/8thrps,	ie ½th of its side (50%).
1/8thrps	it might giv the red 1/16thrps,	ie ½th of its side (50%).
1/16thrps	it might giv the red 1/32thrps,	ie ½th of its side (50%).
1/32ndrps	it might giv the red 1/64thrps,	ie ½th of its side (50%).

See what I meen?? Once the white's initial spin rate fallz below 1/4thV, the *tranzmitted side* iz alwayz 50% (perhaps 49% allowing for energy lossez). In other wordz, the white and the red end up with the same sidespin (but with opposite direction). Theze impakts are full-ball impakts.

I guess that Leslie'z tests were ok, but he probably had som trouble with hiz termz or definitionz. I think that hiz.....***duz not xceed 12%***.....

.....iz comparable to my $\omega_{rps} = 1/8^{th} V_{rpsdrive}$ ***....(4),*** koz 1/8th iz 12.5%.

Leslie probably mezured or estimated the angle of the axis of rotation of the red, and found that it never xceeded 12% from the horizontal, which iz kind'ev like what my Equation (7) sez (it sez 12.5%). Leslie probably uzed Bonzoline ballz, or Cryztalate ballz --- their μ iz i think a little bit less than μ for Krapamith Ballz --- & a little bit more than μ for ivory ballz. Leslie'z stuff kumz completely off the railz if u start looking at impakts that are not full-ball --- koz then a white with zero sidespin kengiv sidespin to the red --- we look at this & other stuff later.

Sets

If the opponent's yellow iz frozen to the red, and the set-line (yellow to red) points to the pocket, uken play a set-shot, hitting yellow to pot the red, az we all know. And, az we all know, uhavta be careful --- if the set-line points to the middle of the pocket uken still miss the shot. Koz, the red will not automatically head straight along the line, ie for the middle of the pocket --- if the yellow iz hit other than straight at the red, the red might be dragged (flicked, thrown) off the pocket-line by up to μ (ie 1cm in 20cm).

And, az we all know, if the set-line iz a little off the pocket, which lookslikeyakarntgetthe pot, umightbeabletagetthepot by intentionally hitting the yellow across the face of the red, so that the flick (throw) givz the pot. In theory uken still get the pot even if the set-line iz upta 1 in 20 off the pocket-line --- or more, if u cheat the pocket. A bit of sidespin on the *q*ball might help.

Dizzy'z Dilemma

Dizzy haz the *q*ball in hand after a foul. The 9ball iz frozen to the 5ball, & the 1ball, 2ball, 3ball & 4ball are down. The 5ball to 9ball set-line points to the ryht-hand jaw of a corner pocket. Dizzy wants to pot the frozen 9ball, which will win the game in one shot.

Where should Dizzy place the qball to maximize her chancez of potting the 9ball ????? Dizzy knowz that if she places the qball ryht (east) of the line, & hits the 5ball full-ball, the 5ball will throw the 9ball towardz the center of the pocket. But Dizzy ken see that it iz going to be a near thing --- she ken see that she needz to maximize the throw. So, with *q*ball in hand, where should she place it to maximize the throw ????? The answer iz.....

Pozzy Dead in line with the 5ball to 9ball line, & about 4 ballz clear of the 5ball.

The next question iz --- what kontakt on the 5ball iz needed ????? Dizzy allready knowz that she hazta hit the ryht-hand-side of the 5ball --- but how thick ????? An 1/8th ball ? --- a ¼ ball ? --- a ½ ball ? --- a ¾ ball ? The answer iz.....

Kontakt A ¼ on the 5ball givz the most throw for the 9ball.

The next question iz --- how should Dizzy hit the 5ball ????? With skrew ? --- or with stun ? --- or with left-hand-side? --- or with ryht-hand-side ? The answer iz.....

Stun Stun iz best --- ryht-hand-side (running) iz poizon.

The next question iz --- should Dizzy hit at dead pace or iz faster betterer ????? The answer iz...

Not Too Hard Medium pace iz best --- not too slow & not too hard.

Pozzy

Dead in line with the 5ball to 9ball line, & about 4 ballz clear of the 5ball, iz best. Here we hav 3 ballz --- there are 2 impakts, both occurring during allmost the same time --- the forcez etc are much much more komplikated than for an ordinary (but very komplikated) 2 ball kollizion. In a 2-ball impakt, 1 unit of throw on the hittee givz 2½ units of spin on the hittee --- a 3-ball kollizion iz different. And perhaps μ iz different --- koz i reckon that there are two μ'z --- μ for a 3-ball kollizion appearz to be greater than μ for a 2-ball kollizion --- or that iz the effekt. Hmmmmmmmm. This duznt really answer our question --- but it iz leeding us in the right direktion.

Kontakt

A ¼ ball kontakt on the 5ball givz the most throw for the 9ball. So, here we see Dizzy shooting at the ryht-hand-side of the 5ball (ie a ¼ ball), from a range of 4 ballz. This kontakt, ¼ ball, givz near'nuff the most tranzmitted side to the yellow --- ryht-hand-side here. The ryht-hand-side on the yellow throwz the red to the left --- see ???????

Remember that 1 unit of flick givz 2½ units of tranzmitted side (in a 2-ball impakt) --- hence, in a 2-ball set (ie a 3-ball impakt), tranzmitted side on the 5ball iz potentially a more powerfull faktor than flick on the 5ball, in its affekt on flicking the 9ball --- see ???????

What i meen iz --- the blind 9ball feelz the friktion of the 5ball brushing across the kontakt. The 9ball wouldn't hav a clue whether this brushing woz due to the speed of a 5ball with zero sidespin mooving in a certain direktion & hitting the 5ball say a half-ball --- or due to a slower 5ball with check-side mooving in a slightly different direktion & hitting thicker than half-ball --- or due to a faster 5ball with running-side mooving in a slightly different direktion & hitting thinner than half-ball --- theze 3 kombinationz would all hav exaktly the same effekt on the speed & direktion & tranzmitted side on the 9ball --- see ??????? In theze 3 instancez i ignore the added komplikation of differencez in topspin, only to save wordage --- uken add the wordz if u like.

Stun

In my tests, stun woz best (for the ¼ ball kontakt). Running side (ryht-hand-side here) iz poizon. We allready sed that ryht-hand-side on the 5ball helps to throw the red in the dezired direktion, ie left, ie away from the jaw. Well, ryht-hand-side on the *q*ball leedz to left-hand-side on the 5ball --- see ?????? In theory i think that som check-side (left-hand-side here) should be best, better than skrew, & better than left-hand-side. But in fakt stun proovd best. Hmmmm. Certainly stun iz eezyr to uze --- more akurat & konsistent. But uze whatever u like to avoid the *q*ball finding a pocket --- but don't uze running-side (ryht-hand-side here).

Not Too Hard

In a 2-ball impakt, harder tendz to giv the hittee (yellow) a wider angle, ie a hard hit ken rezult in a finer cut --- this all dependz on the average contact angle (see chapter 71), which inkreecez with speed due to the larger flatspot at impakt. Here i am talking about the 5ball to 9ball impakt angle. For the same reezon, in the 3-ball impakt, the 9ball'z throw dekreecez with pace --- instead of going wider, the 9ball goze narrower. But in fakt the 9ball duz go wider --- its just that ball-to-ball line & the travel are a mirror image of the 2-ball case --- hence the same effekt rezults in a narrower travel in the 3-ball case .....see ??????. The softer the ball the worse the effekt, ie the bigger the flatspot. But very slow iz not good either --- ruffing up the kontakt needz energy, but don't overdo it.

Tests

I got the abov set-line rezults by doing tests on my home table --- but woz i right --- did i giv Dizzy a bum steer --- try it for yorself. Try other pozzyz, & other kontakts & other sidespinz & other speedz --- find out for yorself --- i doubt that uken do better than what Dizzy did --- altho it would all depend on the xakt nature of yor ballz. This woz all a shock to me ----- the rezults direktly oppozed my gut feelingz --- i wonder how many timez i hav uzed running-side, ie poizon --- but don't forget that all poizonz are medicinz if uken find the right place to uze them. Hmmmmmm. See the following drawing --- Tranzduced 1.

Half-Ball

The ½ ball tests were an eye-opener. Here running-side woz instant death --- instead of inkreecing the throw it reduced it a hellovalot. The throw when the *q*ball woz rolling (zero side) woz 80mm --- slower gave 80mm --- harder gave 70mm --- skrewed gave 83mm --- stunned gave 95mm --- with left-hand-side gave 83mm --- with ryht-hand-side gave 40mm. Hmmmmmmm. Theze tests were from the pozzy etc allready mentioned, ie 4 ballz clear & on the line. But doing good tests iz very difficult, the rezults vary a lot --- koz they vary with pace --- & koz of the soft krappy ballz etc --- & koz of ball-to-ball impakt marks & skuff marks etc.

Quarter-Ball

The throw when the *q*ball woz rolling (zero side) woz 110mm --- skrewed gave 115mm --- stunned gave 125mm, stunned harder gave 100mm, stunned slower gave 115mm --- with left-hand-side gave 115mm --- with ryht-hand-side gave 80mm. Theze tests were from the pozzy etc allready mentioned, ie 4 ballz clear & on the line.

Other Anglez

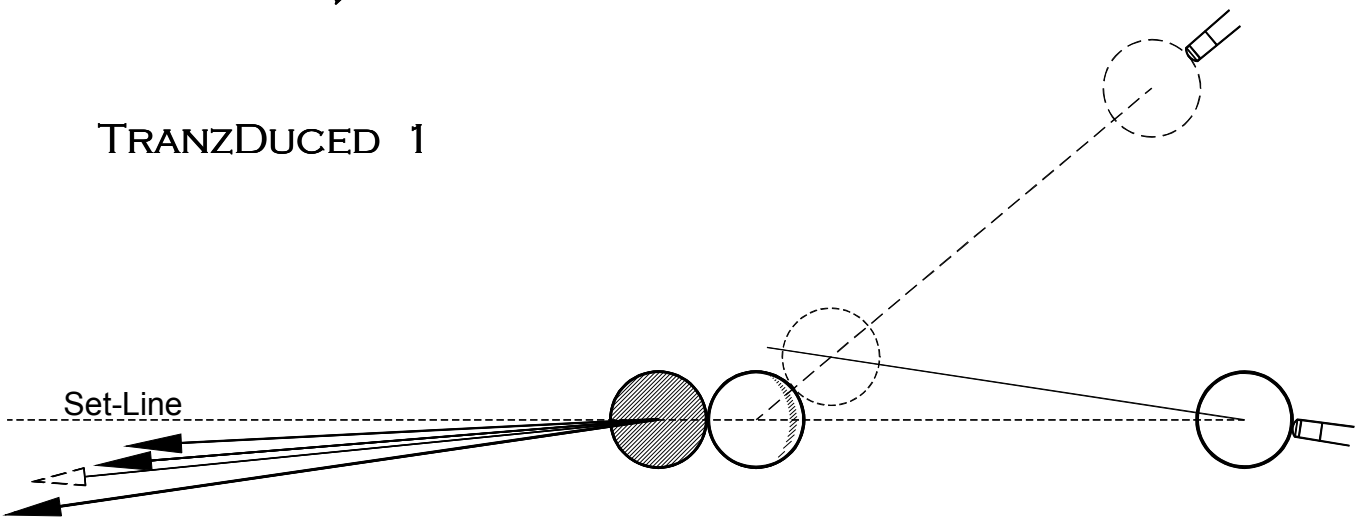
If u moov the *q*ball around to allow u to attack the 5ball from other anglez, u karnt do much better than a flick of 80mm to 90mm. Hitting full-ball on the 5ball, or hitting ½ ball or ¼ ball duznt seem to gain anything. Uzing stun or check-side or skrew duznt seem to gain anything --- running-side being poizon az uzual. Thusly, if Dizzy placez the *q*ball at som funny angle (eg between say 30° & 60°), & hits the 5ball with som funny kontakt (eg between say full-ball & ¼ ball), she won't ever do much better than what she would hav dunn placing the *q*ball on the line & 4 ballz clear & hitting the 5ball ½ ball, ie getting about 80mm or 90 mm of throw. And nowhere near what she would hav gotted stunning at ¼ ball, ie 125mm --- there iz som sort of super-sqeez here. Hmmmmm.

Friktion

125mm of flick in 860mm of roll suggests a μ of 1 in 6.88. When i did a simple full-ball friktion test, uzing just 2 ballz, the impaktor being thrown by hand & uzing finger spin, the flick woz 70mm, which meenz a μ of 1 in 12.29, which iz much more than the 1 in 20 that i got in previous tests. 1 in 20 would re*q*ire a flick of 43mm. In previous tests i uzed varyus types of ballz, but the ballz uzed here were i think a different (older) set of Krapamith (or mightbe Super Crystalate) they feel softer & sound softer i reckon. Hmmmmm.

Sqeez Effekt

TranzDuced 1



μ_3 1 in 6.9

Here the widest arrow showz the best rezult that uken get if u want to throw the red off the ball-to-ball line --- for my testes (ie for my soft krappy ballz) this angle woz 1 in 6.88. Az we sed, it iz got by placing the *q*ball on the ball-to-ball line & 4 ballz clear, & then hitting the yellow ¼ ball (az shown by the dotty ball) at medium pace, with stun. In Dizzy'z Problem the yellow woz the 5ball, & the red woz the 9ball. Az 3 ballz are involved here, i call this μ_3.

Broken Arrow

If u place the *q*ball at other pozzyz, for xample on the line shown by the broken ball, &/or if u try kontakting the yellow thicker or thinner, u will allwayz get a narrower throw for the red, uzually no better than perhaps the broken arrow shown.

μ 1 in 20

The narrowest arrow showz the theoretikal 1 in 20 throw that u might xpekt for the red if the ballz were the standard modern krappy ballz, ie if the ballz had a μ of 1 in 20.

Finger Spin Test μ_2

Remember -- we find μ by doing Fred'z standard test (see Tranzduced 2). We hit the red full-ball uzing finger spin on the *q*ball (finger-ball actually). But this iz a 2-ball test ---- henceforth i will call the apparent friktion rezulting from this test μ_2.

μ_2 1 in 12.3

The 2nd narrowest arrow showz the theoretikal 1 in 12.29 value for μ_2 for the xtra-soft krappy ballz that i unfortunately happened to uze in theze 3-ball tests. I got the 1 in 12.3 by uzing the fingerspin test. I suspekt that theze ballz are allmost az soft az pool ballz --- my ballz are 52.5mm ($2^1/_{16}$") --- i suspekt that the $2^1/_8$" & 2¼" ballz uzed in pool etc are very soft, but it wouldn't worry pool playerz --- perhaps soft $2^3/_8$" would worry 3-cushion playerz, if they knew.

True Friktion -- μ_1

What we need iz a real test to mezure true friktion, ball-to-ball. This might involv 2 ballz --- perhaps pressing one ball onto a spinning ball. It might involv dragging a ball (or 2 or 3) across a flat surface made of the same material. This true friktion iz henceforth called μ_1.

Sqeez & μ_2

So how iz it that μ_2 givz the red a wider throw than μ_1 ?????

It appearz that there iz a sqeez effekt in the finger spin test for μ_2. When the finger-ball first contacts the red the ball-to-ball line iz at say 00.0°. During impakt, the finger-ball moovz ryht, assuming that it haz anticlockwize spin --- the red moovz left, probably an equivalent amount. At the end of impackt the ball-to-ball line might be at say 4.0°. This meenz that at mid-impakt the ball-to-ball line might hav been say 2.0°, but here more likely say 1.4°, depending firstly on how u define mid-impakt (there are at least 4 wayz). Thusly, the sqeez effekt here would hav been +1.4°.

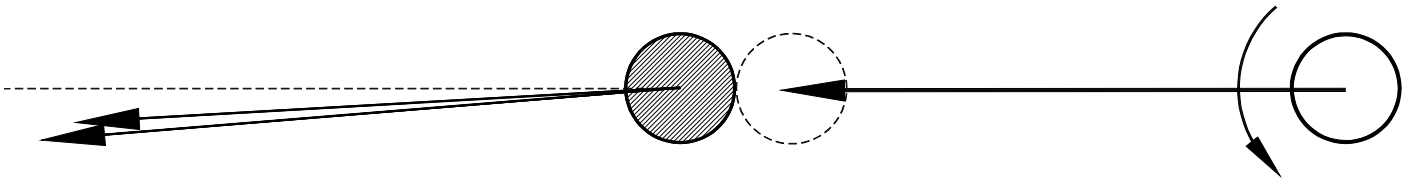
The softer the ball the larger the flatspot & the longer the impakt time (uzually between 0.0003sec for a hi-speed impakt & 0.0010sec for a low-speed impakt) --- hence the softer the ball the larger the sqeez effekt --- perhaps the relationship would be proportional to allmost the power 2 (^2) of the softness (depending on how u define softness).

The faster the impakt the larger the flatspot & hence the larger the sqeez effekt allso. For my krappysoft ballz μ_2 woz 1 in 12.29, or 4.65°. Dedukting 1.4° givz 3.25°, which would suggest that the true (but hypothetikal here) friktion (μ_1) iz 3.25° or 1 in 17.6. See ?????? The sqeez effekt here accounts for 26.7% of the throw --- thusly, in effekt, it inkreecez the friktional throw by 43.1% (in this hypothetikal kase).

Sqeez

So, if the ballz were perfiktly hard, ie if there were no flatspot, ie if the impakt time were zero, then there would be zero sqeez, & hence the maximum throw in any & all impakts would be μ_1. We allready sed that the sqeez ken add 1.4° of throw --- & perhaps this could be az much az 3.0° (just guessing) for a fast impakt uzing very soft ballz.

TranzDuced 2

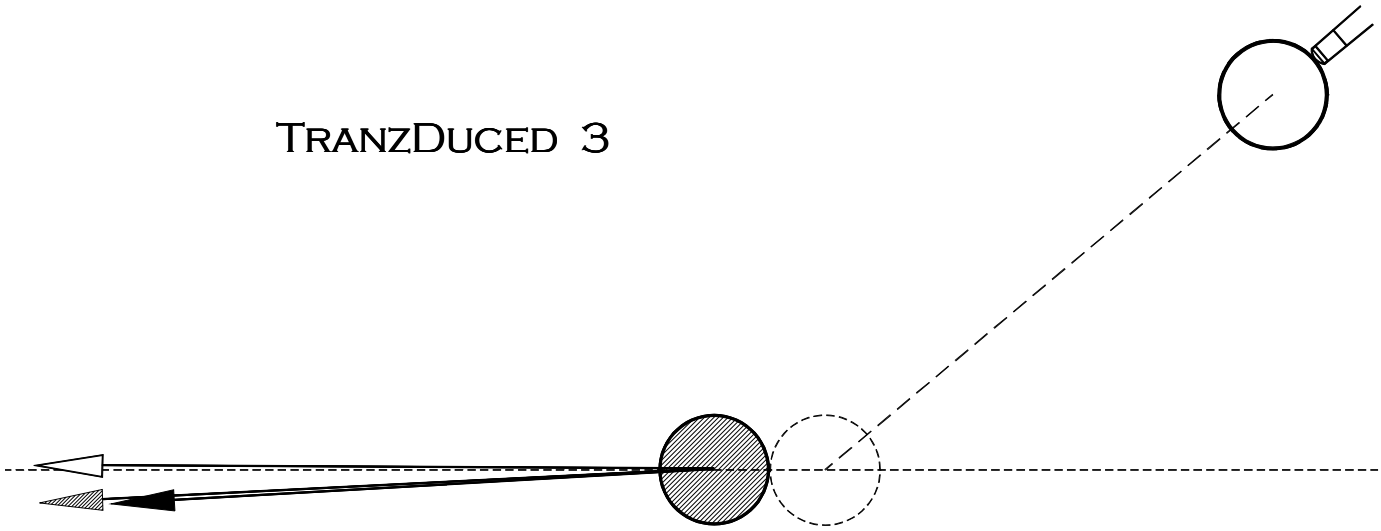


In Tranzduced 2, the narrow angle iz the hypothetikal true throw of 3.25° arizing from true friktion (μ_1). The wider angle iz the mezured throw of 4.65° (μ_2) which inkloodz sqeez.

But there are 2 types of sqeez --- flatspot-sqeez, & friktion sqeez --- we look at theze nextly.

True Sqeez

There are 2 types of μ_2 . In the beforegoing sektion, the sqeez effekt woz pozitiv (ie +1.4°) --- but in allmost every kase in a game, when u are trying to cut the red into a pocket, the sqeez effekt iz negativ. In Tranzduced 3 the *q*ball hits the red thinner than half-ball, with stun. The red should depart at 3.25° (***black arrow***), but we would find that it aktually departs at say 2.75° (the ***grey arrow***). At initial kontakt (the dotty ball) the *q*ball to red line iz the dotty horizontal line.



FlatSpot-Sqeez

Flatspot-sqeez iz the sqeez that u would get if there were zero friktion --- it relyz mainly on the size of the flatspot (i meen the overall deformation of the ball, but the flatspot iz uzually the main ingredient). Hence the flatspot-sqeez iz mainly a geometrik effekt --- & it iz allwayz negativ. Think of it az being the sqeez that u would get if there were zero slippage between ballz --- eg if in Tranzduced 3 the *q*ball had natural side, ie left-hand-side, ie such that there woz zero ball-to-ball slippage during impakt.

I hav kalkulated that for a medium paced half-ball impakt the difference between the initial kontakt angle & the final kontakt angle kenbe 1.0°, & the average iz therefor 0.5°, which i reckon affekts the red'z travel by minus 0.5° kompared to the initial kontakt angle, ie we would say that the flatspot-sqeez iz minus 0.5°, ie we would say that the throw iz minus 0.5°. But throw (friktion) haz nothing to do with it --- depending on how u define throw.

If, in Tranzduced 3, μ_1 woz zero, of if the *q*ball had natural side, the red'z departure angle would be minus 0.5°, az shown by the ***white arrow***.

The faster the impakt, & the finer the kontakt, the larger the flatspot-sqeez --- i suppoze that it could be in the range zero to say minus 1°.

Friktion-Sqeez

Friktion-sqeez iz more komplikated. Friktion ken inkreec the overall sqeez (if there iz enuff running-side), or friktion could dekreec the overall sqeez (if the running-side iz deficient, or if there iz check-side

I think that friktion-sqeez ken affekt the difference between initial & final kontakt by up to plus or minus 4° in a simple 2-ball impakt, ie the red'z travel iz affekted by up to plus or minus 1.4°. The more obvious --- by up to plus or minus 2.0° (instead of 1.4°) --- wouldn't be korrekt in most instancez --- koz the *q*ball'z throw would uzually inkreec gradually (probably linearly) from say zero m/s to its final value, hence the effektiv middle of the impakt would occur 1/3 of the way throo. See?????? Duzzenmadder.

Overall Sqeez

If we take a kase where the flatspot-sqeez iz minus 0.5°, then the overall sqeez could thusly be in the range plus 0.9° to minus 1.9°, depending on the sidespin on the *q*ball.

Back in Tranzduced 2 the total (estimated) sqeez woz 1.4°. Even tho that woz a full-ball impakt, the 1.4° woz not all due to friktion-sqeez. If u think about it, there woz a small amount of flatspot-sqeez here allso, but very little.

Jack Karnhem

In his 1976 book ***Understanding Billiards and Snooker***, Jack sez that the new Super Crystalate ball iz lighter than the old Crystalate ball, and he sez that fine shots hav bekum eezyr & incredibly fine cuts are now possible.

One possible xplanation is that Super Crystalates were softer, ie that the flatspots at impakt were larger than in Crystalate impakts, and that the same fine shot would giv a finer line of travel for the red. In other wordz, the flatspot-sqeez angle woz larger with the new ball.

I reckon that the Aramith & Super Aramith ballz introduced here in the late 80'z perhaps giv similar rezults (ie a similar sqeez) to Super Crystalate.

Tranzmitted Side

When we sed earlyr that 1 rps of flick yieldz 2½ rps of tranzmitted side, we ken now see that we were wrong. Koz it iz only friktion that ken cauze tranzmitted side --- ie only true friktion --- ie only μ_1 . The portion of flick (throw) arizing from sqeez (both types) kontributes zero to tranzmitted side.

Hencly, if sqeez iz negativ, the tranzmitted side iz more than 2½ timez the flick. If sqeez iz pozitiv, the tranzmitted side iz less than 2½ timez the flick. See ??????? Here & elsewhere we are entertaining ourselvz with fyziks & maths --- much of this stuff haz little to do with aktual play.

SuperSqeez & μ_3

So, how iz it that μ_3 givz the red a wider throw than μ_2 ????? Referring to the set-shot shown in Tranzduced 1, it appearz that in a 3-ball impakt there iz somtimez super sqeez --- the line & ¼ ball kontakt shown in Tranzduced 1, & in Dizzy'z Dilemma, producez such super sqeez.

During the early part of the impakt, the *q*ball pushez the yellow south & west, & the yellow pushez the red south & west. If u look at the *q*ball'z kontakt & travel, uken see that this line etc iz very effektiv in trapping the yellow, ie hindering the yellow from going south. The *q*ball givz the yellow ryht-hand-side --- the ryht-hand-side helps to throw the red south. Thusly, even tho the yellow iz itself largely hindered from going south, the ryht-hand-side on the yellow iz fully effektiv in bringing about a full mezure of friktion (μ_1) sending the red south.

If the yellow never ever findz itself ryht of the red (north in Tranzduced 1), then logikally the red ken never be given a travel angle of more than μ_1. Yet we know that μ_3 here iz much more than μ_1. Hmmmmmmm. We know that the yellow iz sent left (south) --- & much moreso than the red --- so the yellow karnt possibly ever be ryht (north) of red. Hmmmmmmm. So, where iz the super-sqeez ??????????

SuperSqeez helps to trap the yellow, & this certainly reducez the flatspot-sqeez (yellow to red) --- remember that flatspot-sqeez iz allwayz negativ (it reducez the red'z departure angle) --- but flatspot-sqeez iz a minor effekt, hence such reducing duznt xplain the high value of μ_3.

The answer to this puzzle iz hidden in the friktion. The answer appearz to be that true friktion (μ_1) ken hav mor than one value --- all of them true. We look at this nextly.

SuperFriktion & μ_1

True friktion ken hav lots of valuez, depending on the nature of the surface(z) of the ball(z) in the flatspot zone(z). μ_1 will hav a higher value if som sort of ball-to-ball impakt mark or skuff mark happenz to get in the ball-to-ball kontakt zone, ie in the flatspot zone --- not to mention chalk, & *q*tip skuff marks etc.

Somtimez it iz an old ball-to-ball impakt mark or skuff mark that duz the dirty deed --- thusly it would be unexpekted & unwanted --- the old mark would cauze a kick of som sort. But it might not be an old mark --- it might be a fresh mark --- koz all ball-to-ball impakts leev a mark, & this mark iz there during much of that original impakt, & it affekts that original impakt. The friktion in a ball-to-ball impakt dependz on what iz happening in the kontakt zone. Ball-to-ball slippage ruffs up the kontakt, & hence μ_1 ken double from say 1 in 17.6 (3.25°) to say 1 in 8 (7.13°).

When one ball hits another ball allmost full-ball with force, it leevz what i call an impakt mark --- but impakt marks do not hav much effekt on friktion. If this ball-to-ball impakt iz a glancing blow, it leevz what i call a skuff mark --- skuff marks ken hav a large effekt, they ken double the friktion.

Logikally if an old skuff mark gets into the kontakt zone, u get a double dose of skuff --- the old skuff plus the new skuff. But, az i sed, new skuff affekts friktion during the original impakt. And, az i sed, μ_1 dependz on what iz happening in the kontakt zone.

My theory iz that ---- if the kontakt zone on each ball iz mooving across the surface of each ball, then much of the surface of each ball (within the flatspot) iz smooth & slippery.

The red iz originally stationary, & the kontakt zone on the red would moov akross the surface mor or less the same amount no matter what the spin on the *q*ball. But the kontakt zone on the *q*ball would moov a lot if the *q*ball had check side, & it would moov a little less if there woz zero sidespin, & it would moov very little (or not at all) if the *q*ball had running-side. Here we are looking at a 2-ball kollizion, not Dizzy'z 3-ball set-line problem that we looked at earlyr, we will kum back to that shortly.

If the kontakt on the *q*ball mooved only a little, then the kontakt zone on the *q*ball would be largely an area of new skuff mark --- hence the friktion would possibly be at a maximum. I think that throw & friktion & tranzmitted side are at a maximum if the ball-to-ball slippage bekumz zero just az impakt endz. U need som slippage otherwize u don't hav any friktion force --- but too much slippage reducez μ_1.

While doing yor own set-line tests, if an old skuff mark duz get in the kontakt, u will soon know it, the red'z throw will be off the chart. U need to polish the 3 ballz very energetikally befor each test --- it appearz that the skuff marks are worse than what iz suffered during 2-ball tests --- which appearz to proov the point --- super-friktion livz here.

STUN on the *q*ball tendz to keep ball-to-ball slippage horizontal --- any vertical slippage & vertical friktion force etc iz largely wasted i think. This would allso apply to Dizzy'z 3-ball problem that we are ment to be addressing here --- hence it xplainz why Dizzy should uze stun.

In Tranzduced 1, the stunned *q*ball'z deviation angle will be much wider than u would xpekt --- u will think that u hav put skrew on the *q*ball --- but the wider deviation angle iz due to the fakt that the yellow will feel heavyr to the *q*ball due to the added mass of the red akting during the double impakt event. See ????????? Anyhow, be wary of this funny angle.

Induced Spin

Dizzy'z problem remindz us thatudonthavtahav sidespin on the qball to giv flick & side to the yellow --- a qball with zero rotation ken induce sidespin on the yellow. If there iz ball-to-ball slippage during impakt, then there will be induced side. We karnt call it tranzmitted side koz there woz zero side on the *q*ball to begin with --- Koehler'z ***Induced Spin*** iz a good name.

Stun

So, a stunned *q*ball hitting the yellow other than full-ball will allwayz induce sidespin on the yellow. And here the yellow will allwayz induce an equivalent opposit sidespin on the *q*ball.

Rolling

Likewize, a rolling *q*ball (with zero sidespin) hitting the yellow other than full-ball will allwayz induce sidespin on the yellow, but not az much sidespin az the stunned *q*ball. The total of the induced sidespin (the horizontal spin) plus the tranzmitted spin (the vertical spin) might in total be more than the sidespin u might get with a stunned *q*ball, but the sidespin (for the rolling *q*ball case) will be less. And here the total spin on the yellow duz not (i think) necessaryly match the change in spin on the *q*ball --- i think that koz the *q*ball had som initial rotational momentum, the spin axis will tilt, hence this tilting abzorbz som of the potential spin. Putting it another way --- the vertical component of the ball-to-ball friktion robz som of the horizontal friktion.

Rolling Impakts

Slippage

In fact, a rolling *q*ball alwayz haz an excess of rotation (ie topspin) --- i meen, when it hits the yellow, the *q*ball will alwayz hav plenty of rotation remaining, no matter what the angle of contact. If it didnt, slippage would occur for the first phase of the impakt, but slippage would cease before impakt finished. If slippage ceasez early, there would be som tranzmitted (& induced) spin, but it would not reech the maximum possible, ie it would not reech 1/8th V. Also in this instance V, the impakt velocity, would not be the *q*ball'z V, it would be the yellow'z V, which would be somwhat less (don't worry about this --- but it might kum up later).

Universal Law

Whenever slippage ceasez early (ie before impakt endz), the *q*ball & yellow end up with the same vertical & horizontal spin, but mirror image. This kenbe sed of any & all impakts, it iz a universal law (ignoring praktikal issuez such az ball-to-cloth friktion during impakt). Anyhow, this (ceasing early) never happenz if the *q*ball haz pure rolling. Lettuce moov on.

TranzDuced Spin

Now, the amount of tranzduced spin (tranzmitted spin plus induced spin), if mezured in rps, iz going to vary depending on the contact, ie whether ¼ ball or ½ ball etc --- it iz zero for a full-ball contact & allmost zero for a fine contact. It will also vary with the speed of impakt, ie obviously if u double the speed u double the tranzmitted side (ignoring lossez). We should ask the following questionz.....

Questionz on Rolling

Q1.....What iz the relationship between contact & tranzduced side ??

Q2.....What contact givz the maximum tranzduced side ??

Q3.....What iz the maximum value of tranzduced side ??

Q4.....Is the tranzduced side that u get from pure rolling less than the tranzduced side that u get from a spinning *q*ball ??

I did a few quick calcs that i hope are ok --- a score of 50 out of a 100 will giv me a Pass.

Firstly, after impakt, the yellow'z velocity iz.....$V = V_{qball} * \text{Sin}\ \theta$ .....where θ iz the *q*ball'z initial deviation angle, ie the standard skoolkid 60° for a ½ ball contact.

Secondly the tranzduced spin iz limited by the impakt velocity, & we know it iz equal to..... ...2½ μ V rps.....or.....1/8thV rps (where V iz the yellow'z velocity in rps, & μ iz 1/20).

Thirdly, the tranzduced side will alwayz be less than 1/8thV, koz there will alwayz be a vertical component of the slippage (ie for all contacts, if the white haz pure rolling). The tranzduced spin will be 1/8thV, but this will be in the plane of the ball-to-ball slippage. The tranzduced side iz the horizontal component of the tranzduced spin..... So.....

$tranzduced\ side = tranzduced\ spin * Cos\varphi$.... where φ iz the angle of the dip of the slippage.

Fourthly, the dip (φ) iz actually equal to the white's initial deviation angle (i worked it out, trust me).....so, luckyly, we ken simply say that.....dip = $\varphi = \theta$ .....

And.....$tranzduced\ side = 1/8 * V_{qball} * \text{Sin}\theta * \text{Cos}\ \theta$ ***.....(5).....***

This answerz Question No 1.

Differentiation givz us the value for θ when $tranzduced\ side$ iz a maximum. I checked my old skool books, & found that $^{d}/_{d\theta} = 1/8 * V_{qball}(\text{Cos}^2\theta - \text{Sin}^2\theta)$

So, if..... $^{d}/_{d\theta} = 0$ ....then....$\text{Cos}\theta = \text{Sin}\theta$ .....so....$\theta = 45$ deg.....

If the ball-to-ball angle iz 45°, then the kontakt iz 0.293, ie 4.7/16, ie a bit thicker than ¼ ball.

This answerz Question No 2.

If....θ iz 45 deg.....$tranzduced\ side = V_{qball}$ / 16 rps..... (where V iz rps).

So, the maximum value of $tranzduced\ side$ = V/16 rps.....

And, if V_{qball} = 1 rps .....then.....$tranzduced\ side$ = 1/16th rps.....

This answerz Question No 3.

This bringz us to ***Question No 4***. ....Iz the $tranzduced\ side$ that u get from pure rolling less than the $tranzduced\ side$ that u get from a spinning qball ?? Well, the answer iz yes.

Remember we had to apply a correction (Cos θ) to allow for the difference between $tranzduced\ spin$ & $tranzduced\ side$. The more sidespin that the qball has, then the less iz θ, & the more iz Cos θ. So, the more sidespin the more $tranzduced\ side$ (for a rolling Qball).

Stun Impakts

Question No 4 showz that a stunned qball ken giv more side than a qball with pure rolling.

There iz no vertical component of slippage, so we ken say that .....

..... *tranzmitted side* = *tranzmitted spin*.

And.....*tranzmitted side* = $1/8 * V1_{qball} * \sin\theta$ .....

Differentiation givz us the value for θ when tranzmitted side iz a maximum. I checked my old skoolbooks, & found that.....

$$\text{.....}^{d}/_{d\theta} = 1/8 * V1_{qball}\cos\theta\text{.....}$$

$$\text{..... So, if.....}^{d}/_{d\theta} = 0 \text{ .....then.....} \cos\theta = 0 \text{ .....so.....} \theta = 90^\circ$$

Unfortunately, this iz wrong --- it givz us θ for the maximum value of the impakt etc....But it duznt giv us the maximum tranzmitted side.....Koz, at 90°, ie full-ball, there iz no slippage between the qball & red, & if there iz no slippage there iz no tranzmitted side .

At a little less than 90° (say at 89°), we will hav a large impakt, but very little slippage. The little slippage that duz xist iz reduced to zero very quickly by the large impakt force & friktion, so that slippage reducez to zero well before the time that the ballz part company.

So, what we want to find iz the largest contact angle that rezults in the slippage reducing to zero at the xakt instant that the ballz part company. This will giv the maximum tranzmitted side (for a stunned qball). And, both ballz will hav the same sidespin, ie the red will tranzmit an equal amount of sidespin to the qball. Neither ball will hav any topspin before the impakt (by definition), & none at the end of the impakt, but of course both ballz gain topspin later.

Now, the maximum tranzmitted side possible iz $1/8^{th} V2_{red}$ rps, for any contact. Az a first guess I would say that this might be acheeved when the contact angle iz 1 in 20, ie 2.8624°, or θ = 87.1376° (where 90° iz full-ball). But lettuce see.

The final velocity of the qball iz $V1_{qball}\cos\theta$ (if no friktion, ie if no tranzmitted side). If there iz friktion, ie if tranzmitted side, the final velocity iz actually only $5/7^{ths}$ of $V1_{qball}\cos\theta$ (if slippage stops just az the ballz part, or befor). If so, the tranzmitted side (rps) equalz the qball'z final velocity (mezured in rps).

Now, for this special case....

..... 5/7ths V2qball $\cos\theta$ should equal 2 * 1/8thV2red rps.....

..... if the red & qball hav the same sidespin. Also, we know that, in any & all cases,

V2red = V1qball $\sin\theta$ (if no friktion).

Friktion actually increasez $V2_{red}$, but, for the purposez of theze equationz, we don't hav to worry about that. We only need to know the component of the impakt acting along the line of the centerz of the ballz, ie az if there woz no friktion. This iz the value of $V2_{red}$ we need in the equation. The additional friktional component, which sendz the red off with a little more velocity & at a slightly different angle, iz not the $V2_{red}$ we need for the above equation.

.....So, $5/7^{ths}$ $V2_{qball}$ $Cos\theta$ will equal 2 * $1/8^{th}V2_{red}$ rps..... if the red & qball hav the same sidespin. Also, we hav $V2_{red} = V1_{qball} Sin\theta$ (if no friktion).

.....So..... $5/7^{ths}$ $V2_{qball}$ $Cos\theta$ = 2 * $1/8^{th}$ $V2_{qball}$ $Sin\theta$ .....so.....20/7 = Tan θ .....

.....So, we get..... θ = artan 20/7..... so..... θ = 70.71 deg (ie the qball'z exit angle after impakt) ....so the contact angle iz 19.29 deg. This iz approx 5½ /16^{ths} off full-ball.

This contact givz us the maximum possible tranzmitted side for a stunned Qball. A thicker contact will giv progressively less tranzmitted side, koz slippage ceasez befor the ballz part, koz there iz not enuff slippage to make use of all of the available impakt force. And at 90 deg the tranzmitted side (and slippage) bekum zero.

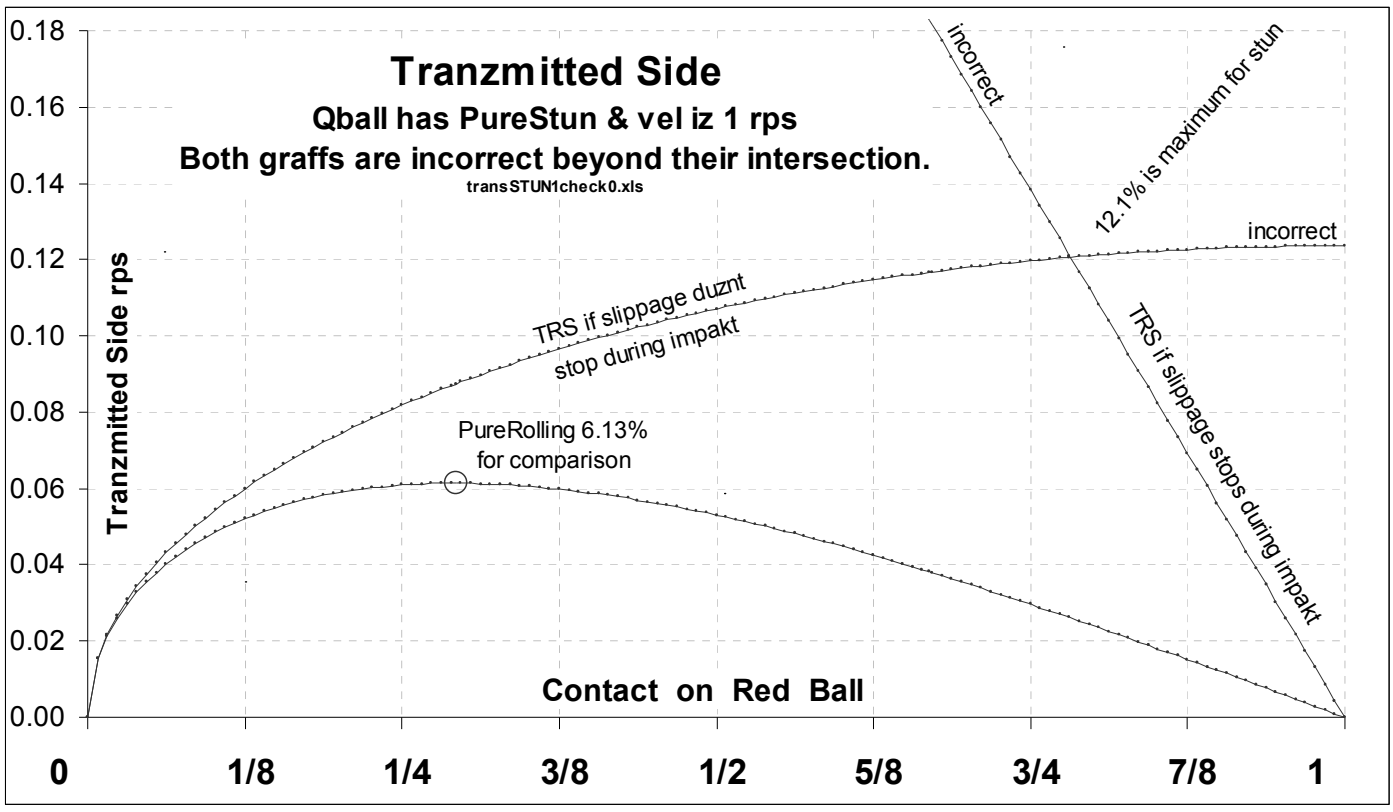
For thick contacts (slippage stops before the ballz part) the final velocity of the qball iz $5/7^{ths}$ of $V2_{qball}$ $Cos\theta$. The tranzmitted side (rps) equalz the qball'z final velocity (rps).

A thinner contact will also giv progressively less tranzmitted side, koz the qball will hav excess slippage, ie the impakt force will not be large enuff to make use of all of the available slippage. The tranzmitted side will be $1/8^{th}V_{red}$, & it will bekum zero when the contact bekumz 0° .

Now.....$V2_{red}$ = $V1_{qball}$ $Sin\theta$ .....(if no friktion).....so, for the thinner contacts.... .....*tranzmitted side* = $1/8^{th}$ $V1_{qball}$ $Sin\theta$

The friktion force ken never xceed μ * impakt force. Which iz the same az saying that V_{flick} ken never exceed μ * V_{red}.

TranzDuced 4



Kicks

The phenomenon of flick & tranzmitted side kenbe called a kick. A kick occurz in every impakt where tranzmitted side (or tranzmitted spin) occurz, ie in every impakt where there iz ball-to-ball slippage. There are good kicks & there are bad kicks.

Good Kicks

The good kick iz our standard ball to ball contact, & it occurz during every clean collizion, if there iz ball-to-ball slippage. Playerz don't think of the good kick az a kick at all. They xpect it, & rely on it --- they take it for granted.

Bad Kicks

If the kick iz not the normal size, then we ken call it a bad kick. The red & the white ken take wretched directionz, weird anglez, bizarre spinz & hideous velocityz. The white uzually jumps up clear of the table, & the normal click of a clean collizion iz often replaced by a sickening thud , followed by *shit* from the player, a gasp from the spectatorz, & an unconvincing *bad luck* from the opponent.

Negativ Kicks

Somtimez a kick iz invizible, but bad enuff to rob u of a score. And somtimez the kick iz smaller than normal, ie when the ball to ball friktion iz reduced by sweat on a ball, or oil, fat, soap, moisture, saliva, hair, or whatever --- this iz a sort of negativ kick, the friktion iz less than 1 in 20.

1 in 20

Earlyr, I mentioned that a normal kick ken giv a flick of up to 30mm for a drive of 600mm, which iz a deflection angle of 1 in 20, or 5%.

1 in 4

Anyhow, when I put som chalk dust on the red, the red woz flicked 150mm when driven 600mm, which givz a deflection angle of 1 in 4, or 25%.

1 in 6

When I put a qtip chalk mark on the red, the red woz flicked 100mm when driven 600mm, which givz a deflection angle of 1 in 6, or $16^2/_3$%.

Therefore, bad kicks are up to 5 timez az powerful az a good kick. This iz the sort of thing that often happenz during play --- the culprit iz uzually a qtip chalk mark --- no wonder kicks cauze so much trouble.

Not to forget all of the invizible baby kicks, that are more common than we realize, due to very small amounts of chalk, or due to old impakt skuff marks, or whatever. We think we stuffed up again, when perhaps we should blame the referee for not keeping the ballz az clean (or polished) az possible --- unhygienic ballz. Refereez uzually wear cotton glovez for theze purposez.

Krapamith

But, in the modern era, we hav a new demon, the modern krapamith --- the devil duznt need chalk to do hiz dirty work, he haz a soft, high-polish, small ball. They are eezy to wipe & clean, & they look great, but they are very lively & varyabl, & u get the impression that mini-kicks (or somthing) hav been inklooded in the rezin. Hmmmmm.

Useful Shot No 1

Somtimez ukenuze throw / flick to make it eezy to judge the angle for a pot red. Say the red iz on its spot, & the qball iz very near the red & a little off a straight line to the corner pocket. Uken just aim for the center of the red, & uze the necessary amount of side on the qball to giv the necessary flick to get the pot.

For me, this iz sortuv eezyr & quicker than finding the correct angle for the correct contact for a plain ball shot with no side. Especially if the white & red are very close, which would ordinaryly need a very thin contact on the red to pot it. Theze thin cuts are alwayz difficult to judge, & the Qball needz to be hit hard. Uzing side lets u aim thicker on the red, & the white duzn't hav to be hit hard. But this method needz praktis if u want to hav confidence in it.

I feel that ikengetupta 150mm of flick. The distance from the spot to the pocket iz 930mm, so 1/20 would giv upta 46mm of flick. So obviously I get the xtra 104mm koz I drag & swerve the Qball off line with the cue without know'en it.

Useful Shot No 2

Somtimez ukenuze tranzmitted side to make it eezyr to pot the red when the red iz very close to the cushion. On som tablez the red won't go in if it touchez the cushion before the pocket. But, ifya put side on the qball, to tranzmit pocket-side to the red, the red ken drop even tho it hits the cushion first. Pocket-side iz sidespin that helpsta throw the ball into the pocket off the far jaw. Som playerz reckon that it makes pots eezyr, especially when the pocket iz slightly blind, & they reckon it's well worth the xtra difficulty in judging the shot.

Useful Shot No 3

If the opponent's yellow iz frozen to the red, & the set-line iz the pocket-line, uken play a set-shot to pot the red. But, uhavta be careful. If the set-line iz to the middle of the pocket, uken still miss the shot. Koz, the red will not automatically head straight for the pocket. If the firstball iz hit other than straight at the red, the red will be dragged off the pocket-line. So, uhavta contact the firstball very nearly on the line, and/or uhavta put sidespin on the qball to flick the firstball closer to the line..

And, if the set-line iz a little off the pocket, which lookslikeyukarnt get the pot, umightbeabletagetthepot by intentionally hitting the firstball across the face of the red, so that the flick givz the pot. See Dizzy'z Dilemma. Uken still get the pot even if the set-line iz more than 1 in 20 off the pocket-line. A bit of sidespin on the Qball ken also help. Sidespin on the qball puts tranzmitted side on the firstball, which in turn helps to flick the red. So, ukenget more than 1 in 20 --- but be careful --- its eezy to uze the wrong sidespin (ie running-side) & find that uhav lost flick. Hmmmmmm.

More On Kicks

I woz having lunch with Refereez Harold Silver & Henry Checutti during the 1998 World Amateur Billiardz Championship at the RACV club in Melbourne, & the discussion turned to kicks. Kicks are a common topic of conversation or argument among playerz, & many hav their own theoryz az to what cauzez kicks. During lunch we came up with a few interesting ideaz, & I hav added a few later thorts. There are lots of happeningz that kenbe called a kick, or that arize from a kick. We allready mentioned Good Kicks. Bad Kicks fall into 4 categoryz i think.

Kicks due to chalk in the kontakt.

Kicks due to an exotik substance, ie other than chalk.

Kicks due to suface imperfectionz on the ball.

Spot kicks.

The Standard Loozer

I tested a number of foreign substancez, & unuzual surface conditionz, on the effect theze had on the standard billiardz center-spot loozer, played off a red ball placed on the center spot, the *q*ball being played from the standard pozzy in the D (ie 70mm from the yellow spot). A smooth stroke (pure rolling) & an accurate half ball contact (or a five-eighths contact) on a clean red will rezult in the *q*ball entering the center of the ryht-top-pocket, & the red kumming around off three cushionz to stop near the center-spot (or near the ryht middle pocket).

Billiard Chalk

A very light sprinkling of billiard chalk on the red cauzed the *q*ball to miss the in-off most of the time. Over a number of tests the *q*ball hit the side cushion say 0mm to 100mm before the pocket, ie the angle taken by the *q*ball woz too wide. There must hav been a kick, but the *q*ball did not jump noticeably & there woz no obvious change in sound of the uzual click of impakt.

I hav often seen a light sprinkling of chalk dust on a red during a billiardz match --- it showz up on the red particularly well --- but dust iznt so obvious when on the yellow or white.

Playerz somtimez unintentionally get chalk on their fingerz & it ken end up on a ball if they handle it. I suppoze that mooving a ball by hitting it with the side of the cue ken cauze chalk to kum off the *q*tip & onto the ball. Perhaps a ball ken pick up chalk while rolling, perhaps with the help of electrostatic attraction. The *q*tip often throwz a spray of dust onto the *q*ball.

This sort of silent, sneaky kick possibly occurz more often than one thinks --- & it must be the cauze of many missed in-offs & cannonz. Every billiardz player haz mysteriously missed an eezy in-off --- -- it destroyz your confidence.

The kick rezulting from a light sprinkling of chalk dust would also slightly affect the direction of the red, possibly ruining an attempted pot-red --- the angle taken by the red would be narrower than xpected.

A qtip chalk mark Ken often be seen on the *q*ball. But for out test we put a *q*tip chalk mark on the red (by firstly uzing it az a *q*ball). This *q*tip chalk mark on the red cauzed the *q*ball to miss the in-off all of the time. The *q*ball uzually hit the side cushion 100mm to 300mm before the pocket. The *q*ball jumped a little & there woz no clean click. This iz obviously the most common type of bad kick xperienced by billiardz playerz.

Close xamination of a *q*ball during play ken somtimez reveal 1 or 2 fresh *q*tip chalk marks & 1 or 2 older, fainter *q*tip chalk marks. Somtimez there iz a large area of chalk dust around the *q*tip mark. Theze marks wipe off naturally during play, in time. I think that the marks (chalk depozits) are worse in humid conditionz --- anyhow, the problem iz obviously worse on som dayz --- perhaps it iz worse if u carry the chalk in your pocket, where it iz humid, especially if the adrenalin iz flowing.

*Q*tip marks are often very large --- a *q*tip iz say 10mm in diameter & a *q*tip mark iz often say 5mm in diameter but more often it iz oval in shape. *Q*tip marks ken be xpected on the *q*ballz (theze are white & yellow) --- but I hav often seen theze marks on the red, obviously koz the red had been handled with the cue. In the abov tests the mark woz placed on the red to save time --- i suppoze that i could hav covered a *q*ball with lots of *q*tip marks, but this would hav been too much of a hit or miss test (mainly miss).

A heavy layer of chalk smeared on the red cauzed the *q*ball to miss the in-off all of the time. The *q*ball uzually hit the side cushion 300mm to 600mm before the pocket --- the *q*ball jumped a lot & there woz no clean click of impakt. This type of mark (ie a very thick layer of chalk) would never occur during a match --- i did it just to see what happened.

A small speck of billiard chalk placed on the red cauzed the *q*ball to miss the in-off most of the time. Over a number of tests the *q*ball hit the side cushion 0mm to 300mm before the pocket. Any of the 3 ballz ken pick up a speck of chalk --- however I think this iz rarer than we think --- the main culprit iz the *q*tip chalk mark.

Surface Imperfectionz

Impakt marks Ball-to-ball impakt marks ken be found on the ballz after any full-ball type of impakt, but they are more eezyly seen on the red. The marks are uzually faint, & up to 5mm diameter --- they are eezyly rubbed off the ball. In tests, theze marks did not cauze any obvious kicks nor any missed in-offs.

Skuff marks Ball-to-ball skuff marks ken be found on the ballz after any glancing impakt --- they karnt be eezyly rubbed off. No in-offs were missed, but the *q*ball often hit the near jaw of the pocket before entering.

Kick skuff marks Skuff marks cauzed by a ball-to-ball chalk kick are i think very severe --- & if u see such a mark u will uzually see that it inkloodz a trace of the original chalk --- they karnt be eezyly rubbed off. I didn't do any tests, but i reckon that kick marks would ruin some loozerz.

Qtip skuff marks Chalk helps to prevent misscuez koz the chalk partiklez are very angular & hav hi internal friktion. And koz the chalk iz abraziv. The chalk scratchez the ball, inkreecing the ball-to-ball μ. This scratching, or skuff mark, polishez away in time. I don't remember doing any center-spot loozer tests for *q*tip skuff marks, but i gess that som loozerz would be missed --- here i don't meen the *q*tip chalk marks mentioned earlyr.

Scratchez A small area of an old red woz scratched with sandpaper. At first, this cauzed the *q*ball to miss the center spot loozer all of the time, the *q*ball uzually hit the side cushion say 100mm to 500mm before the pocket. The *q*ball jumped a little & there woz no clean click of impakt. Later, after a number of impakts, the scratched area appeared to bekum smoother, & the loozer woz successful most of the time. Freshly scratched ballz would be rare, but old scratchez are somtimez seen, & theze could possibly cauze a small kick. Ballz ken be accidentally scratched if knocked off the table into a brick wall, or if a pocket haz xpozed screwz, or if the nailz holding the bedcloth are expozed in the pocket, etc.

Exotik Substancez

Cooking Oil For lunch i bort a meat pie --- oil (fat) from the bottom of the pie woz smeared onto the red. The *q*ball missed the loozer every time, hitting the end cushion 0mm to 100mm left of the pocket, ie the *q*ball took a narrow angle off the red. The *q*ball did not jump, & there woz a clean click at impakt. This iz a case where the normal good kick (giving the dezired good angle) iz prevented by the slippery oil. The oil would not affect the impakt force, but it would reduce the friktion force. Az there iz less friktion force, the *q*ball loozez less forward rotation at impakt, & therefore the *q*ball takes a narrower path. Handling oily food whilst playing billiardz could leed to this sneaky kick, & the player iz left with no clue to xplain the reazon for the miss. The poor player blamez hiz judgement of the in-off angle. The next time he placez the *q*ball for an in-off he allowz for a narrower angle, and, getting the normal good kick (this time), he missez the in-off too wide. By this time the player iz a basket-case & goez on to looz the match by a mile.

Hair Oil woz not tested, but it would hav the same effect az Cooking Oil, ie missing the loozer too narrow all of the time. Hair Oil haz been uzed by cheats in the past, to cause their opponent to miss*q* or to giv a narrow-kick.

Detergent Full strength detergent had a similar effect to Cooking Oil. Washing both ballz in a strong detergent bath, then drying before testing, did not hav any effect on the in-off at all. I hav heard a tale regarding the strange behavior of a set of snooker ballz after washing in detergent, but my tests did not reveal any effect.

Saliva cauzed the *q*ball to hit the left jaw of the pocket, to run narrow, but it entered the pocket most of the time.

Perspiration Wiping the red on my forehead cauzed the *q*ball to hit the left jaw occazionally, ie it cauzed a minor narrow-kick. Perspiration iz probably a bigger problem than most playerz realize, especially in club matchez where the refereez (ie other playerz & yor team mates) do not wear glovez. In tournament play the official refereez would be wearing glovez, but a player would handle her own *q*ball, & playerz handz are allwayz hot & sweaty.

Cigarette Ash This had a similar effect to Billiard Chalk, ie some loozerz were missed koz the *q*ball ran too wide.

Pseudo Spot Kicks

Normal spots There iz allwayz a reaction between the red & the bedcloth during a ball-to-ball impakt, & this reaction affects the ball-to-ball impakt itself.

If the *q*ball haz topspin, friktion pushez the red downwardz, inkreecing the red to bed force --- the red to bed friktion acts to reduce the tranzmitted spin (bottom spin mainly) on the red --- & it allso acts to slow the red --- thusly inkreecing the ball-to-ball impakt time --- thusly wasting more energy than uzual --- thusly taking more topspin off the *q*ball than uzual (depending on what *uzual* meenz).

If the *q*ball haz stun (zero sidespin & zero topspin) the red to bed reaktionz will still exist but will be negligible.

If the *q*ball has bottom spin (skrew) the red will be pushed up, hence the *q*ball will go down --- thusly inkreecing the *q*ball to bed reaktion during impakt --- thusly wasting more energy & taking topspin off the *q*ball.

The abov refer to the red sitting on the bedcloth. If the red iz sitting on the billiard spot, the red to spot friktion might be more than the red to bed friktion --- alltho, spots are i think made of silk, perhaps koz silk haz low friktion.

If for som reezon the spot haz hi friktion, the final outkum might be the same az if there woz a small ball-to-ball kick --- it iz a pseudo kick. U might find turnabout for a full-ball impakt the red might not reech the corner pocket (a real problem). Allso, for a non-full-ball impakt, the red might run off-line & hit the jaw (but here i think not badly enuff to rob the pot).

Sunken spots Theze sorts of spots are a very kommon menace. The spot or the cloth might be worn, & hence the red sits in a small depression or hole --- now the pseudo kick iz violent. The red to spot reaktion iz more severe --- partly koz of the angle of the "hill", & partly koz the ball-to-ball impakt time iz much prolonged.

All pseudo kicks are especially bad for slow impakts, koz the ball-to-ball impakt time iz longer, hence the reaktion with the spot or bed iz more effektiv.

All pseudo kicks are especially bad for soft krapamith ballz, koz their impakt timez are longer. All of this sort of stuff iz poizon when playing floating-yellow.

Mostly, sunken spots are sunken due to a build up of chalk under the cloth --- chalk migrates to the spot & then stayz there --- its more a kase of a raized cloth then a sunken spot.

U havta push a needle throo the cloth to break up the chalk depozit & to spread it around --- & don't forget to scratch the underside of the cloth, koz a lot of the chalk adherez to the underside. U will havta repeat this often --- untill perhaps the cloth iz taken up to restretch it, or untill it iz replaced with a new cloth.

Wet spots When the red won't sit properly on the spot, my team mates lick a finger & wipe it on the spot, & then push the red down into the spot. I don't know whether this works. But i do know that a wet spot haz higher friktion --- it often akts az if it iz a sunken spot.