Tranzmitted Side

If the during impakt the qball's surface **SLIDES** akross the (stationary) red's surface then both balls will suffer an equal & opposite tangential **FRIKTION** force which will change the rotation of both balls (by an equal & opposite amount probly). In addition there will allso be a pair of equal impakt forces acting center to center which will change the velocity of both balls (by an equal & opposite amount probly), that change being along that center to center line. Plus the tangential friktion force (in addition to changing the rotations) will change the velocity of both balls in that tangential direction (by an equal & opposite amount probly), which we call **THROW**. We talk of redball throw but we don't uzually mention qball throw. Anyhow, the red will (initially) head off along a line & with a velocity that accord with the sum of the impakt vector & the throw vector. A qball with **NATURAL ENGLISH** will not induce any sidespin on the red (ie rotation about the vertical axis) but it can induce rotation about a horizontal axis (eg screw or follow). A qball with natural english karnt induce any throw of the red (ie in the horizontal) but it kan make the red **HOP** (ie in the vertical). Natural english iz when the qball haz sidespin such that there iz zero horizontal slippage when it hits the red. A qball kan hav lots of screw or lots of follow, in addition to having natural english. Anyhow, induced sidespin on the red iz called **TRANZMITTED SIDE**. And we kan allso hav tranzmitted follow or tranzmitted skrew. Throw iz tranzmitted throw but we never call it that. The correct term iz **INDUCED SIDE** (Koehler). Me myself i like **TRANZDUCED SIDE**. Impakts involv time & distance, koz both balls share a temporary **FLATSPOT** during impakt. The center to center line during impakt moovs throo an angle from first kontakt to last kontakt. Krapps often show a visible **IMPAKT MARK**, which iz huge after a hi-speed impakt (koz krapps are so soft). Tons haz been written re this stuff, & basically almost everyone haz been 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.

MY COMMENTS Simpson is partly wrong , u karnt hav throw without tranzmitted side.

WILLIE SMITH Willie believed in tranzmitted side, but did not understand throw.
KEITH SIMPSON Believed in throw, but did not believe in tranzmitted side.
RISO LEVI Sid not beleev in tranzmitted side nor throw.
FRED LINDRUM Fred Lindrum believed in tranzmitted side & throw. Strangely, in later years he denied the existence of tranzmitted side & throw.

Fred Lindrum
Spot End Billiards Technique and First Principles 1913

Dolly sed that Fred woz very studyus & well read, this excerpt supports 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 ***deflexion*** *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 Billiards Arithmetically Treated, here are some snippets.

Fred uzed the term flick, nowadays it iz uzually called throw. My tests showed that the red woz flicked 30mm when driven 600mm, which givs a deflexion angle of 1 in 20, or 5% , or 2.86°. This shows that the ball to ball friktion force (acting tangentially) iz 5% of the ball to ball impakt force (acting on the line of the centers). 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 materials uzed to make the ball, ie ivory, phenolic rezin, etc. Or, more correctly, the material on the surfaces of the balls, koz modern krapps hav a secret kleer surface coating.

Flick Tests Uzing Qball

The above tests were done uzing lots of fingerspin, & I couldn't be sure that they were realistic, ie that they could occur in actual play. So I carryd out some 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 angles, & with varyus amounts of sidespin on the qball, & I mezured where the red hit the cushion. The flick woz sometimes 75mm in 1500mm, which iz exactly 1 in 20. For some tests I put varyus foreign substances between the white & red, ie a little chalk or lots of chalk, & theze gave a flick of up to 305mm. Saliva gave 20mm. A hair gave 30mm. Uzing chalk, & hitting hard, uzually created a scuffmark on the red (which sometimes 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, & could be expected in actual play, ie uzing a cue. A few times, 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 reminds me that we recently had to stop a match, to replace one of our sets of billiards balls, koz the red woz badly scuffed, & the rezulting number of kicks woz farcical. Obviously, someone had been hitting the balls very hard in praktis, probly praktising screw shots, & hence woz uzing lots of chalk, but he had not bothered to keep the balls 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 kinds of scuff marks..... (i) qtip-qball, (ii) qball-2ndBall (impakt), (iii) qball-2ndBall (impakt plus kick).

Tranzmitted Side

Ok, we know about the flick & deflexion 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 (x) units of tranzmitted side, & there iz a simple equation linking the two, applying to all solid spheres. It would be different for other shapes, ie for solid cylinders, hollow tubes etc. I hav allways been amazed that the educated professionals & amateur scientists of old did not realize this, & i fear that few moderns hav bothered to do the math. Anyhow, I'm not going to wait any longer, here it iz.

$$Vrps = {}^{2}/_{5}\,\omega rps \qquad \text{or} \qquad \omega rps = 2½\ Vrps \quad ......(1)$$

The tranzmitted sidespin (ω rps) mezured in rev/sec, iz 2½ times the flick (Vrps).

This answers our earlyer question, it tells us that one unit of flick, ie 1.0 rps, will yield 2.5 rps of tranzmitted side, this applys to all solid spheres, ie all makes of ball. It's a surprizing rezult. U would think that one unit of flick (rps) would giv one unit of tranzmitted side (rps), or even a lot less. But the 1 to 2½ ratio iz a fixed relationship that applys to all solid spheres. It meens 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 kan do more.

So, from (4) & (5) $\qquad \omega$ rps = 2½ μ Vrps drive ....(2) for all solid spheres.

For our red, μ = 1/20th $\qquad$ so $\qquad \omega$ rps = 1/8th Vrps drive ...(3) for my red only.

Note that I don't meen that the red iz rolling at some number of rps, i meen that the red's actual straight line velocity (m/s) iz expressed az rps, rolling or not. It just makes things eezyer to talk about, koz I prefer to describe the tranzmitted side in rps. Anyhow, m/s or rps, it makes no difference to theze equations. Equation (6) iz the one we were looking for. It applys to all solid spheres. It givs u 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 knows what μ iz for their balls. All of this type of analysis iz for interest only, but then again if it helps you to be aware of things that kan 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 kan 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. I guess that the friktion of other brands of balls might be different. I cheated a little in the flick tests, koz I uzed the very large 63mm Super Aramith balls, theze were eezyer to test (more consistent & more accurate) than my small 52.5mm Super Aramith balls. By the way, equations (4), (5) & (6) do not need the uzual qualification

"if there are no energy losses at impakt". Theze equations are ok the way they are, koz the flick woz mezured, ie it's not theoretical. Theoretical things often need that kind of apology.

Example

A hard hit will send a Qball (white) heading 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 oodles of sidespin, & it iz skidding with zero or very little topspin, & 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 deflexion angle of the red would be 1 in 20, or 5%. We assume that the deflexion angle iz μ (but actually it drops with speed). And we assume that there iz enuff sidespin on the white, & not much topspin (topspin friktion would rob some of the horizontal friktion). Praps i should hav sed that the deflexion 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 losses). Simple az that. When it hits the red, the white will looz all that it givz the red. It loozes 40 rps of velocity, & it loozes 5 rps of sidespin. But it duz gain something. 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 speeds are just after impakt, i don't take into account any ball to bed skidding losses or rolling losses that a ball suffers (or enjoys) 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 kan 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 losses). And the deflexion 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 & 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 sometime during impakt, & the white & red will end up with equal (but opposite) spins.

TopSpin

If a qball haz lots of sidespin & lots of topspin before it hits the red, then there will be less tranzmitted side. The friktion forces & the tranzmitted spins in varyus examples might be the same size, but the rubbing contact between the balls might not be in the same direction. In our example 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, &, therefore, the tranzmitted side would be less (in proportion). This iz partly due to my convention, or Fred's convention really. He assumed that tranzmitted side iz the horizontal component of the ball's rotation. Anyhow, it kind of makes this article simpler, koz flick iz basically horizontal also. Az i didn't explain earlyer, if there iz a little topspin i suspekt that the red's deflexion angle could possibly be increased a tiny bit due to massé (ie it could be more than 1 in 20), but lots of topspin would reduce the deflexion angle, ie it would be a little less than 1 in 20, or a lot less.

Leslie Kidner's Tests

I woz interested to read the March 1951 edition of The Billiard Player. Leslie Kidner, a Civil and Structural Engineer, & a top amateur billiards 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 always in the range 0% to 50%, not Leslie's 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) tells us that it kan giv the red up to 1/8th of 1rps of side, ie up to 1/8thrps. So, if this white woz spinning at say......

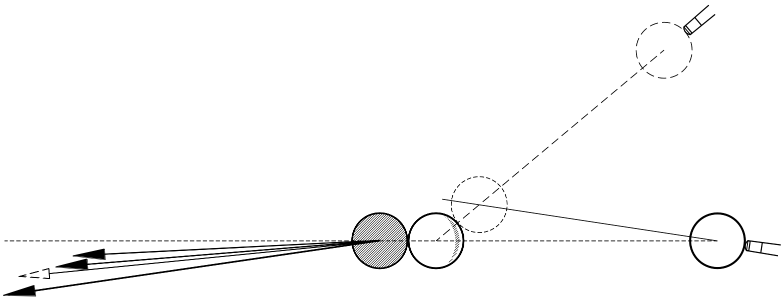
10 rps	it might giv the red 1/8thrps,	ie1/80th	of its side	(1.25%).
1 rps	it might giv the red 1/8thrps,	ie 1/8th	of its side	(12.5%).
¼thrps	it might giv the red 1/8thrps,	ie ½th	of its side	(50%).
1/8thrps	it might giv the red 1/16thrps,	ie ½th	of its side	(50%).
1/16thrps	it might giv the red 1/32thrps,	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 falls below 1/4th V, the tranzmitted side iz always 50% (praps 49% allowing for energy losses). In other words, 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's tests were ok, but he probly had some trouble with hiz terms or definitions. I think that hiz.... duz not exceed 12%.. iz comparable to my ωrps = 1/8th Vrps drive (4), koz 1/8th iz 12.5%.
Leslie probly mezured or estimated the angle of the axis of rotation of the red, & found that it never exceeded 12% from the horizontal, which iz kind of like what my Equation (7) sez (it sez 12.5%). Leslie probly uzed Bonzoline balls, or Crystalate balls, their μ iz i think a little bit less than μ for Krappamyths, & a little bit more than μ for ivory balls. Leslie's stuff kums completely off the rails if u start looking at impakts that are not full-ball, koz then a white with zero sidespin kan giv sidespin to the red, we look at this & other stuff later.

Sets

If the opponent's yellow iz frozen to the red, & the set-line (yellow to red) points to the pocket, u kan play a set-shot, hitting yellow to pot the red, az we all know. And, az we all know, u hav to be careful, if the set-line points to the middle of the pocket u kan 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 looks like u karnt get the pot, u might be able to get the pot by intentionally hitting the yellow across the face of the red, so that the flick (throw) givs the pot. In theory u kan still get the pot even if the set-line iz up to 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's 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 right-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 chances of potting the 9ball? Dizzy knows that if she places the qball right (east) of the line, & hits the 5ball full-ball, the 5ball will throw the 9ball towards the center of the pocket. But Dizzy kan see that it iz going to be a near thing, she kan see that she needs 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 balls clear of the 5ball. The next question iz, what kontakt on the 5ball iz needed? Dizzy allready knows that she haz to hit the rhs 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 lhs? or with rhs? The answer iz..... **Stun** Stun iz best, rhs (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 balls clear of the 5ball, iz best. Here we hav 3 balls, there are 2 impakts, both occurring during allmost the same time, the forces etc are 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 givs 2½ units of spin on the hittee, a 3-ball kollizion iz different. And praps μ iz different, koz i reckon that there are two μ's, μ for a 3-ball kollizion appears to be greater than μ for a 2-ball kollizion, or that iz the effekt. This duznt really answer our question, but it iz leeding us in the right direktion. **Kontakt** A ¼ ball kontakt on the 5ball givs the most throw for the 9ball. So, here we see Dizzy shooting at the rhs of the 5ball (ie a ¼ ball), from a range of 4 balls. This kontakt, ¼ ball, givs near'nuff the most tranzmitted side to the yellow, rhs here. The rhs on the yellow throws the red to the left. Remember that 1 unit of flick givs 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. What i meen iz, the blind 9ball feels 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 kombinations would all hav exaktly the same effekt on the speed & direktion & tranzmitted side on the 9ball. In theze 3 instances i ignore the added komplikation of differences in topspin, only to save wordage, u kan add the words if u like. **Stun** In my tests, stun woz best (for the ¼ ball kontakt). Running side (rhs) iz poizon. We allready sed that rhs on the 5ball helps to throw the red in the dezired direktion, ie left, ie away from the jaw. Well, rhs on the qball leeds to lhs on the 5ball. In theory i think that some check-side (lhs here) should be best, better than skrew, & better than lhs. But in fakt stun proovd best. Certainly stun iz eezyer to uze, more akurat & konsistent. But uze whatever u like to avoid the qball finding a pocket, but don't uze running-side (rhs here). **Not Too Hard** In a 2-ball impakt, harder tends to giv the hittee (yellow) a wider angle, ie a hard hit kan rezult in a finer cut, this all depends on the average contact angle (see Ch71), which inkreeces 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 dekreeces 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. 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 pozzys, & other kontakts & other sidespins & other speeds, find out for yorself, i doubt that u kan do better than what Dizzy did, alltho it would all depend on the exakt nature of yor balls. This woz all a shock to me, the rezults direktly oppozed my gut feelings, i wonder how many times i hav uzed running-side, ie poizon, but don't forget that poizons are medicins if u kan find the right place to uze them. 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 hell ov a lot. The throw when the qball woz rolling (zero side) woz 80mm, slower gave 80mm, harder gave 70mm, skrewed gave 83mm, stunned gave 95mm, with lhsgave 83mm, with rhs gave 40mm. Theze tests were from the pozzy etc allready mentioned, ie 4 balls 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 balls, & koz of ball-to-ball impakt marks & skuff marks. **Quarter-Ball** The throw when the qball woz rolling (zero side) woz 110mm, skrewed gave 115mm, stunned gave 125mm, stunned harder gave 100mm, stunned slower gave 115mm, with lhs gave 115mm, with rhs gave 80mm. Theze tests were from the pozzy etc allready mentioned, ie 4 balls clear & on the line. **Other Angles** If u moov the qball around to allow u to attack the 5ball from other angles, 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 places the qball at some funny angle (eg between say 30° & 60°), & hits the

5ball with some funny kontakt (eg between say full-ball & ¼ ball), she won't ever do much better than what she would hav dunn placing the qball on the line & 4 balls 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 some sort of super-sqeez here. **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 balls, the impaktor being thrown by hand & uzing finger spin, the flick woz 70mm, which meens 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 reqire a flick of 43mm. In previous tests i uzed varyus types of balls, but the balls uzed here were i think a different (older) set of Krappamyth (or mightbe Super Crystalate) they feel softer & sound softer i reckon.



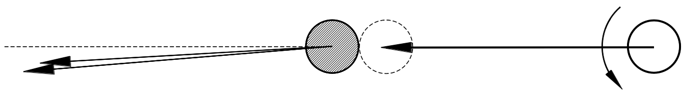
Sqeez Effekt Tranzduced 1

μ_3 1 in 6.9 Here the widest arrow shows the best rezult that u kan get if u want to throw the red off the ball-to-ball line, for my tests (ie for my soft krapps) 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 balls clear, & then hitting the yellow ¼ ball (az shown by the dotty ball) at medium pace, with stun. In Dizzy's Problem the yellow woz the 5ball, & the red woz the 9ball. Az 3 balls are involved here, i call this μ_3. **Broken Arrow** If u place the *q*ball at other pozzys, for example on the line shown by the broken ball, &/or if u try kontakting the yellow thicker or thinner, u will allways get a narrower throw for the red, uzually no better than praps the broken arrow shown. **μ 1 in 20** The narrowest arrow shows the theoretikal 1 in 20 throw that u might expekt for the red if the balls were the standard modern krapps, ie if the ball had a μ of 1 in 20. **Finger Spin Test μ2** Remember we find μ by doing Fred's 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. **μ2 1 in 12.3** The 2nd narrowest arrow shows the theoretikal 1 in 12.29 value for μ_2 for the extra-soft krappy balls 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 balls are allmost az soft az pool balls, my balls are 52.5mm ($2^1/_{16}$"), i suspekt that the $2^1/_8$" & 2¼" balls uzed in pool etc are very soft, but it wouldn't worry pool players, praps soft $2^3/_8$" would worry 3-cushion players, if they knew.

True Friktion – μ1

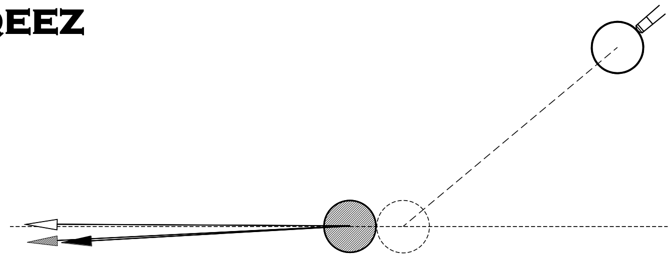
What we need iz a real test to mezure true friktion, ball-to-ball. This might involv 2 balls, praps pressing one ball onto a spinning ball. It might involv dragging a ball (or 2 or 3) across a flat surface made of the same material. This true friktion iz henceforth called μ_1.

Sqeez & μ2 So how iz it that μ_2 givs the red a wider throw than μ_1? It appears 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 moovs right, assuming that it haz anti-clockwize spin, the red moovs left, probly an equivalent amount. At the end of impakt the ball-to-ball line might be at say 4.0°. This meens 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 ways). 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, praps 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 krapps μ_2 woz 1 in 12.29, or 4.65°. Dedukting 1.4° givs 3.25°, which would suggest that the true (but hypothetikal here) friktion (μ_1) iz 3.25° or 1 in 17.6. The sqeez effekt here accounts for 26.7% of the throw, thusly, in effekt, it inkreeces the friktional throw by 43.1% (in this hypothetikal kase). **Sqeez** So, if the balls 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 kan add 1.4° of throw, & praps this could be az much az 3.0° (just guessing) for a fast impakt uzing very soft balls.



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

True Sqeez



TranzDuced 3 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 qball 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 qball to red line iz the dotty horizontal line. **FlatSpot-Sqeez** iz the sqeez that u would get if there were **ZERO** friktion, it relys 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 allways **NEGATIV**. Think of it az being the sqeez that u would get if there were zero slippage between balls, eg if in Tranzduced 3 the qball had **NATURAL** side, ie lhs, 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 kan be 1.0°, & the average iz therefor 0.5°, which i reckon affekts the red's 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, or if the qball had natural side, the red's 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 kan 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 kan affekt the difference between initial & final kontakt by up to plus or minus 4° in a simple 2-ball impakt, ie the red's 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 instances, koz the qball's 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. **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 qball. 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 Understanding Billiards and Snooker 1976

Jack sez that the new Super Crystalate ball iz lighter than the old Crystalate ball, & he sez that fine shots hav bekum eezyr & incredibly fine cuts are now possible. One possible explanation is that **Super Crystalates** were softer, ie that the flatspots at impakt were larger than in

Crystalate impakts, & that the same fine shot would giv a finer line of travel for the red. In other words, the flatspot-sqeez angle woz larger with the new ball. I reckon that the Aramith & Super Aramith balls introduced here in the late 80's praps giv similar rezults (ie a similar sqeez) to Super Crystalate.

Tranzmitted Side When we sed earlyer that 1 rps of flick yields 2½ rps of tranzmitted side, we kan now see that we were wrong. Koz it iz only friktion that kan 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. Hence, if sqeez iz negativ, the tranzmitted side iz more than 2½ times the flick. If sqeez iz pozitiv, the tranzmitted side iz less than 2½ times the flick. Here & elsewhere we are entertaining ourselvs with physics & maths, much of this stuff haz little to do with aktual play.

SuperSqeez & µ3 So, how iz it that μ_3 givs the red a wider throw than μ_2 ? Referring to the set-shot shown in Tranzduced 1, it appears that in a 3-ball impakt there iz sometimes super sqeez, the line & ¼ ball kontakt shown in Tranzduced 1, & in Dizzy's Dilemma, produces such super sqeez. During the early part of the impakt, the *q*ball pushes the yellow south & west, & the yellow pushes the red south & west. If u look at the *q*ball's kontakt & travel, u kan see that this line etc iz very effektiv in trapping the yellow, ie hindering the yellow from going south. The *q*ball givs the yellow rhs, the rhs helps to throw the red south. Thusly, even tho the yellow iz itself largely hindered from going south, the rhs 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 finds itself right of the red (north in Tranzduced 1), then logikally the red kan never be given a travel angle of more than μ_1. Yet we know that μ_3 here iz much more than μ_1. We know that the yellow iz sent left (south), & much moreso than the red, so the yellow karnt possibly ever be right (north) of red. So, where iz the super-sqeez? Super-Sqeez helps to **TRAP** the yellow, & this certainly reduces the flatspot-sqeez (yellow to red), remember that flatspot-sqeez iz allways **NEGATIV** (it reduces the red's departure angle), but flatspot-sqeez iz a minor effekt, hence such reducing duznt explain the high value of μ_3. The answer to this puzzle iz hidden in the friktion. The answer appears to be that true friktion (μ_1) kan hav mor than one value, all of them true. We look at this nextly.

SuperFriktion & µ1 True friktion kan hav lots of values, depending on the nature of the surface(s) of the ball(s) in the flatspot zone(s). μ_1 will hav a higher value if some sort of ball-to-ball impakt mark or **SKUFF** mark happens to get in the ball-to-ball kontakt zone, ie in the flatspot zone, not to mention chalk, & *q*tip skuff marks etc. Sometimes 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 some kind. 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 depends on what iz happening in the kontakt zone. Ball-to-ball slippage ruffs up the kontakt, & hence μ_1 kan 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 leevs 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 leevs what i call a skuff mark, skuff marks kan hav a large effekt, they kan 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 depends 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 more 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's** 3-ball set-line problem that we looked at earlyer, 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 bekums **ZERO** just az impakt ends. U need some slippage otherwize u don't hav any friktion force, but too much slippage reduces 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's throw will be off the chart. U need to **POLISH** the 3 balls very energetikally befor each test, it appears that the skuff marks are worse than what iz suffered during 2-ball tests, which appears to proov the point, **SUPER-FRIKTION** livs here. **STUN** on the *q*ball tends 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's 3-ball problem that we are ment to be addressing here, hence it explains why Dizzy should uze stun. In Tranzduced 1, the stunned *q*ball's deviation angle will be much wider than u would expekt, 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. Anyhow, be wary of this funny angle.

Induced Spin

DIZZY'S problem reminds us that u don't hav to hav sidespin on the qball to giv flick & side to the yellow, a qball with zero rotation kan 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's **INDUCED SPIN** iz a good name.

STUN So, a stunned *q*ball hitting the yellow other than full-ball will allways induce sidespin on the yellow. And here the yellow will allways 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 allways 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 some initial rotational momentum, the spin axis will tilt, hence this tilting abzorbs some of the potential spin. Putting it another way, the vertical component of the ball-to-ball friktion robs some of the horizontal friktion.

Rolling Impakts

SLIPPAGE In fact, a rolling *q*ball always 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 ceases early, there would be some 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's V, it would be the yellow's V, which would be somewhat less (don't worry about this, but it might kum up later). **UNIVERSAL LAW** Whenever slippage ceases early (ie before impakt ends), the *q*ball & yellow end up with the same vertical & horizontal spin, but mirror image. This kan be sed of any & all impakts, it iz a universal law (ignoring praktikal issues such az ball-to-cloth friktion during impakt). Anyhow, this (ceasing early) never happens if the *q*ball haz pure rolling. **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 losses). We should ask the following **QUESTIONS**.

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. **FIRSTLY** after impakt, the yellow's velocity iz......$V = V_{qball} * \sin\theta$ .....where θ iz the *q*ball's 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's velocity in rps, & μ iz 1/20). **THIRDLY** the tranzduced side will always 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 * Cosφ....* 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 kan simply say that....dip = $\varphi = \theta$......

And.............*tranzduced side* = $1/8 * V_{qball} * \sin\theta * \cos\theta$ ***...........(5)***

This answers Question No 1.

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

So, if......$d/d\theta = 0$ ....then....$\cos\theta = \sin\theta$ .....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 answers 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 answers Question No 3.

This brings 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.

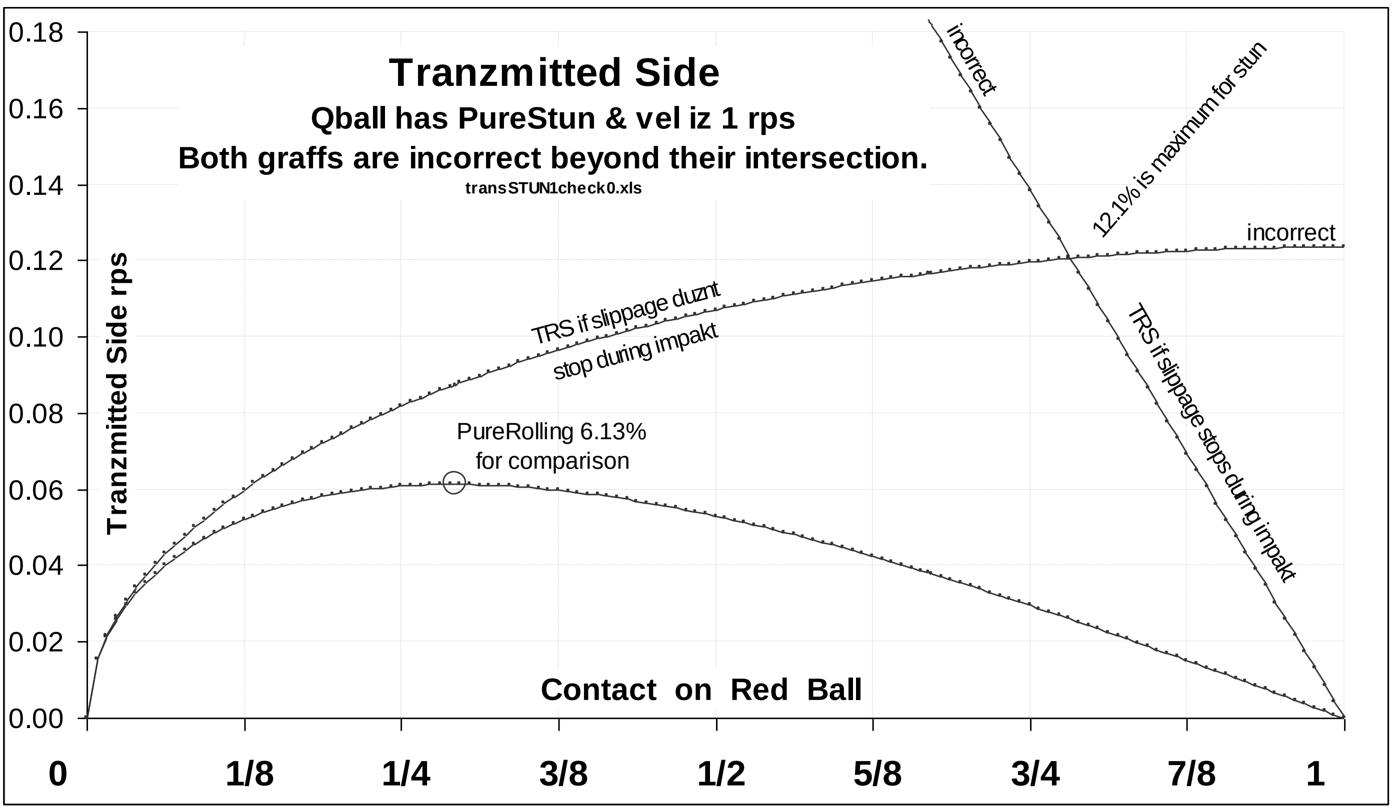
Remember we had to apply a correction (Cos θ) to allow for the difference between *tranzduced spin* & *tranzduced side*. The more sidespin that the qball has, then the less iz θ, & the more iz Cos θ. So, the more sidespin the more *tranzduced side* (for a rolling Qball).

STUN IMPAKTS

Question No 4 showz that a stunned qball kan giv more side than a qball with pure rolling. There iz no vertical component of slippage, so we kan say that .... *tranzmitted side* = *tranzmitted spin*. And.... *tranzmitted side* = $1/8 * V1_{qball} * \sin\theta$ ...... Differentiation givs us the value for θ when tranzmitted side iz a maximum. I checked my old skoolbooks, & found that $d/d\theta = 1/8 * V1_{qball} \cos\theta$

So, if.... $d/d\theta = 0$ ..... then...... $\cos\theta = 0$ .... so......$\theta = 90°$ Unfortunately, this iz wrong, it givs 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 exist iz reduced to zero very quickly by the large impakt force & friktion, so that slippage reduces to zero well before the time that the balls part company. So, what we want to find iz the largest contact angle that rezults in the slippage reducing to zero at the exakt instant that the ballz part company. This will giv the maximum tranzmitted side (for a stunned qball). And, both balls 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 $V1_{qball}$ Cosθ (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 $V1_{qball}$ Cosθ (if slippage stops just az the ballz part, or befor). If so, the tranzmitted side (rps) equalz the qball's final velocity (mezured in rps). Now, for this special case.... 5/7ths V2qball Cosθ should equal 2 * 1/8thV2red rps... if the red & qball hav the same sidespin. Also, we know that, in any & all cases, V2red = V1qball Sinθ (if no friktion). Friktion actually increases $V2_{red}$, but, for the purposes of theze equations, we don't hav to worry about that. We only need to know the component of the impakt acting along the line of the centers of the balls, ie az if there woz no friktion. This iz the value of $V2_{red}$ we need in the equation. The additional friktional component, which sends 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, $5/7^{ths}$ $V2_{qball}$ Cosθ will equal 2 * $1/8^{th}V2_{red}$ rps..... if the red & qball hav the same sidespin. Also, we hav $V2_{red}$ = $V1_{qball}$ Sinθ (if no friktion). So..... $5/7^{ths}$ $V2_{qball}$ Cosθ = 2 * $1/8^{th}$ $V2_{qball}$ Sinθ..... so...... 20/7 = Tan θ ...... So, we get..... θ = artan 20/7..... so.......θ = 70.71 deg (ie the qball's exit angle after impakt).... so the contact angle iz 19.29 deg. This iz approx 5½ $/16^{ths}$ off full-ball. This contact givs us the maximum possible tranzmitted side for a stunned Qball. A thicker contact will giv progressively less tranzmitted side, koz slippage ceases befor the balls 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 balls part) the final velocity of the qball iz $5/7^{ths}$ of $V2_{qball}$ Cosθ. The tranzmitted side (rps) equals the qball's 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 bekums 0°. Now..... $V2_{red}$ = $V1_{qball}$ Sinθ.....(if no friktion).... so, for the thinner contacts.... *tranzmitted side* = $1/8^{th}$ $V1_{qball}$ Sinθ The friktion force kan never exceed μ * impakt force. Which iz the same az saying that V_{flick} kan never exceed μ * V_{red}.

TranzDuced 4



Kicks

The phenomenon of flick & tranzmitted side kan be called a kick. A kick occurs in every impakt where tranzmitted side (or tranzmitted spin) occurs, ie in every impakt where there iz ball-to-ball slippage. There are good kicks & there are bad kicks. The **GOOD KICK** iz our standard ball to ball contact, & it occurs during every clean collizion, if there iz ball-to-ball slippage. Players don't think of the good kick az a kick at all. They expect it, & rely on it, they take it for granted. If the kick iz not the normal size, then we kan call it a **BAD KICK**. The red & the white kan take wretched directions, weird angles, bizarre spins & hideous velocitys. 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 spectators, & an unconvincing bad luck from the opponent. Sometimes a kick iz invizible, but bad enuff to rob u of a score. And sometimes 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 Earlyer, I mentioned that a normal kick kan giv a flick of up to 30mm for a drive of 600mm, which iz a deflexion angle of 1 in 20, or 5%. **1 in 4** Anyhow, when I put some chalk dust on the red, the red woz flicked 150mm when driven 600mm, which givs a deflexion 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 givs a deflexion angle of 1 in 6, or $16^2/_3$%. Therefore, bad kicks are up to 5 times az powerful az a good kick. This iz the sort of thing that often happens 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 praps we should blame the referee for not keeping the balls az clean (or polished) az possible, unhygienic balls. Referees uzually wear cotton gloves for theze purposes. But, in the modern era, we hav a new demon, the modern **KRAPPAMYTH,** 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 & varyable, & u get the impression that mini-kicks (or something) hav been inklooded in the rezin.

Useful Shot No 1 Sometimes u kan uze 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. U kan 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 sort of eezyer & 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 needs praktis if u want to hav confidence in it. I feel that i kan get up to 150mm of flick. The distance from the spot to the pocket iz 930mm, so 1/20 would giv up to 46mm of flick. So obviously I get the extra 104mm koz I drag & swerve the Qball off line with the cue without knowing it.

Useful Shot No 2 Sometimes u kan uze tranzmitted side to make it eezyer to pot the red when the red iz very close to the cushion. On some tables the red won't go in if it touches the cushion before the pocket. But, if u put side on the qball, to tranzmit pocket-side to the red, the red kan drop even tho it hits the cushion first. Pocket-side iz sidespin that helps to throw the ball into the pocket off the far jaw. Some players reckon that it makes pots eezyer, especially when the pocket iz slightly blind, & they reckon it's well worth the extra 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, u kan play a set-shot to pot the red. But, u hav to be careful. If the set-line iz to the middle of the pocket, u kan still miss the shot. Koz, the red will not automatically head straight for the pocket. If the first ball iz hit other than straight at the red, the red will be dragged off the pocket-line. So, u hav to contact the first ball very nearly on the line, &/or u hav to put sidespin on the qball to flick the first ball closer to the line. And, if the set-line iz a little off the pocket, which looks like u karnt get the pot, u might be able to get the pot by intentionally hitting the first ball across the face of the red, so that the flick givs the pot. See Dizzy's Dilemma. U kan 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 kan also help. Sidespin on the qball puts tranzmitted side on the first ball, which in turn helps to flick the red. So, u kan get more than 1 in 20, but be careful, its eezy to uze the wrong sidespin (ie running-side) & find that u hav lost flick.

More On Kicks I woz having lunch with Referees Harold Silver & Henry Chetcutti during the 1998 World Amateur Billiards Championship at the RACV club in Melbourne, & the discussion turned to kicks. Kicks are a common topic of conversation or argument among players, & many hav their own theorys az to what cauzes kicks. During lunch we came up with a few interesting ideas, & I hav added a few later thorts. There are lots of happenings that kan be called a kick, or that arize from a kick. We allready mentioned Good Kicks. Bad Kicks fall into 4 categorys i think. Kicks due to chalk in the kontakt. Kicks due to an exotik substance, ie other than chalk. Kicks due to surface imperfections on the ball. Spot kicks.

The Standard Loozer I tested a number of foreign substances, & unuzual surface conditions, on the effect theze had on the standard billiards center-spot loozer, played off a red ball placed on the center spot, the qball 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 qball entering the center of the right-top-pocket, & the red kumming around off three cushions to stop near the center-spot (or near the right middle pocket).

Billiard Chalk A very light sprinkling of billiard chalk on the red cauzed the qball to miss the in-off most of the time. Over a number of tests the qball hit the side cushion say 0mm to 100mm before the pocket, ie the angle taken by the qball woz too wide. There must hav been a kick, but the qball 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 billiards match, it shows up on the red particularly well, but dust iznt so obvious when on the yellow or white. Players sometimes unintentionally get chalk on their fingers & it kan end up on a ball if they handle it. I suppoze that mooving a ball by hitting it with the side of the cue kan cauze chalk to kum off the qtip & onto the ball. Praps a ball kan pick up chalk while rolling, praps with the help of electrostatic attraction. The qtip often throws a spray of dust onto the qball. This sort of silent, sneaky kick possibly occurs more often than one thinks, & it must be the cauze of many missed in-offs & cannons. Every billiards player haz mysteriously missed an eezy in-off, it destroys 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 expected. A qtip chalk mark kan often be seen on the qball. But for out test we put a qtip chalk mark on the red (by firstly uzing it az a qball). This qtip chalk mark on the red cauzed the qball to miss the in-off all of the time. The qball uzually hit the side cushion 100mm to 300mm before the pocket. The qball jumped a little & there woz no clean click. This iz obviously the most common type of bad kick experienced by billiards players. Close examination of a qball during play kan sometimes reveal 1 or 2 fresh qtip chalk marks & 1 or 2 older, fainter qtip chalk marks. Sometimes there iz a large area of chalk dust around the qtip mark. Theze marks wipe off naturally during play, in time. I think that the marks (chalk depozits) are worse in humid conditions, anyhow, the problem iz obviously worse on some days, praps it iz worse if u carry the chalk in your pocket, where it iz humid, especially if the adrenalin iz flowing. Qtip marks are often very large, a qtip iz say 10mm in diameter & a qtip mark iz often say 5mm in diameter but more often it iz oval in shape. Qtip marks kan be expected on the qballs (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 qball with lots of qtip 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 qball to miss the in-off all of the time. The qball uzually hit the side cushion 300mm to 600mm before the pocket, the qball 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 qball to miss the in-off most of the time. Over a number of tests the qball hit the side cushion 0mm to 300mm before the pocket. Any of the 3 balls kan pick up a speck of chalk, however I think this iz rarer than we think, the main culprit iz the qtip chalk mark.

Surface Imperfections Ball-to-ball impakt marks kan be found on the balls 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. Ball-to-ball skuff marks kan be found on the balls after any glancing impakt, they karnt be eezyly rubbed off. No in-offs were missed, but the qball often hit the near jaw of the pocket before entering. 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 inkloods 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 loozers. Chalk helps to prevent misscues koz the chalk partikles are very angular & hav hi internal friktion. And koz the chalk iz abraziv. The chalk scratches the ball, inkreecing the ball-to-ball μ. This scratching, or skuff mark, polishes away in time. I don't remember doing any center-spot loozer tests for qtip skuff marks, but i gess that some loozers would be missed, here i don't meen the qtip chalk marks mentioned earlyer. A small area of an old red woz scratched with sandpaper. At first, this cauzed the qball to miss the center spot loozer all of the time, the qball uzually hit the side cushion say 100mm to 500mm before the pocket. The qball 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 balls would be rare, but old scratches are sometimes seen, & theze could possibly cauze a small kick. Balls kan be accidentally scratched if knocked off the table into a brick wall, or if a pocket haz expozed screws, or if the nails holding the bedcloth are expozed in the pocket, etc.

Exotik SubstaNCES For lunch i bort a meat **PIE**, oil (fat) from the bottom of the pie woz smeared onto the red. The qball missed the loozer every time, hitting the end cushion 0mm to 100mm left of the pocket, ie the qball took a narrow angle off the red. The qball 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 qball loozes less forward rotation at impakt, & therefore the qball takes a narrower path. Handling oily food whilst playing billiards could leed to this sneaky kick, & the player iz left with no clue to explain the reazon for the miss. The player blames her judgement of the in-off angle. The next time she places the qball for an in-off she allows for a narrower angle, &, getting the normal good kick (this time), she misses the in-off too wide. **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 misscue or to giv a narrow-kick. Full strength **DETERGENT** had a similar effect to Cooking Oil. Washing both balls 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 balls after washing in detergent, but my tests did not reveal any effect. **Saliva** cauzed the qball to hit the left jaw of the pocket, to run narrow, but it entered the pocket most of the time. Wiping the red on my forehead cauzed the qball to hit the left jaw occazionally, ie it cauzed a minor narrow-kick. **Perspiration** iz probably a bigger problem than most players realize, especially in club matches where the referees (ie other players & yor team mates) do not wear **GLOVES**. In tournament play the official referees would be wearing gloves, but a player would handle her own qball, & players hands are allways hot & **SWEATY**. **CIGARETTE ASH** This had a similar effect to Billiard Chalk, ie some loozers were missed koz the qball ran too wide.

PSEUDO SPOT KICKS Normal spots There iz allways a reaction between the red & the bedcloth during a ball-to-ball impakt, & this reaction affects the ball-to-ball impakt itself. If the qball haz topspin, friktion pushes the red downwards, 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 qball than uzual (depending on what uzual meens). If the qball haz stun (zero sidespin & zero topspin) the red to bed reaktions will still exist but will be negligible. If the qball has bottom spin (skrew) the red will be pushed up, hence the qball will go down, thusly inkreecing the qball to bed reaktion during impakt, thusly wasting more energy & taking topspin off the qball. 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, praps koz silk haz low friktion. If for some 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 krapps, koz their impakt times 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 stays 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 adheres to the underside. U will havta repeat this often, untill praps the cloth iz taken up to re-stretch 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.