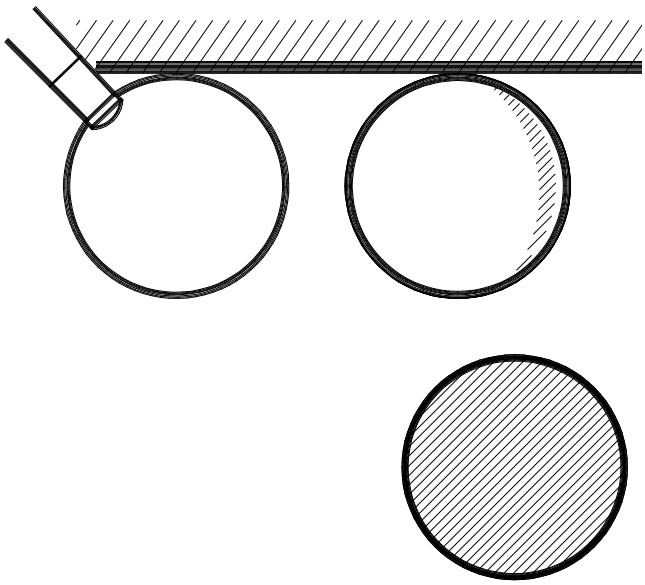
# Deflexion Anglz

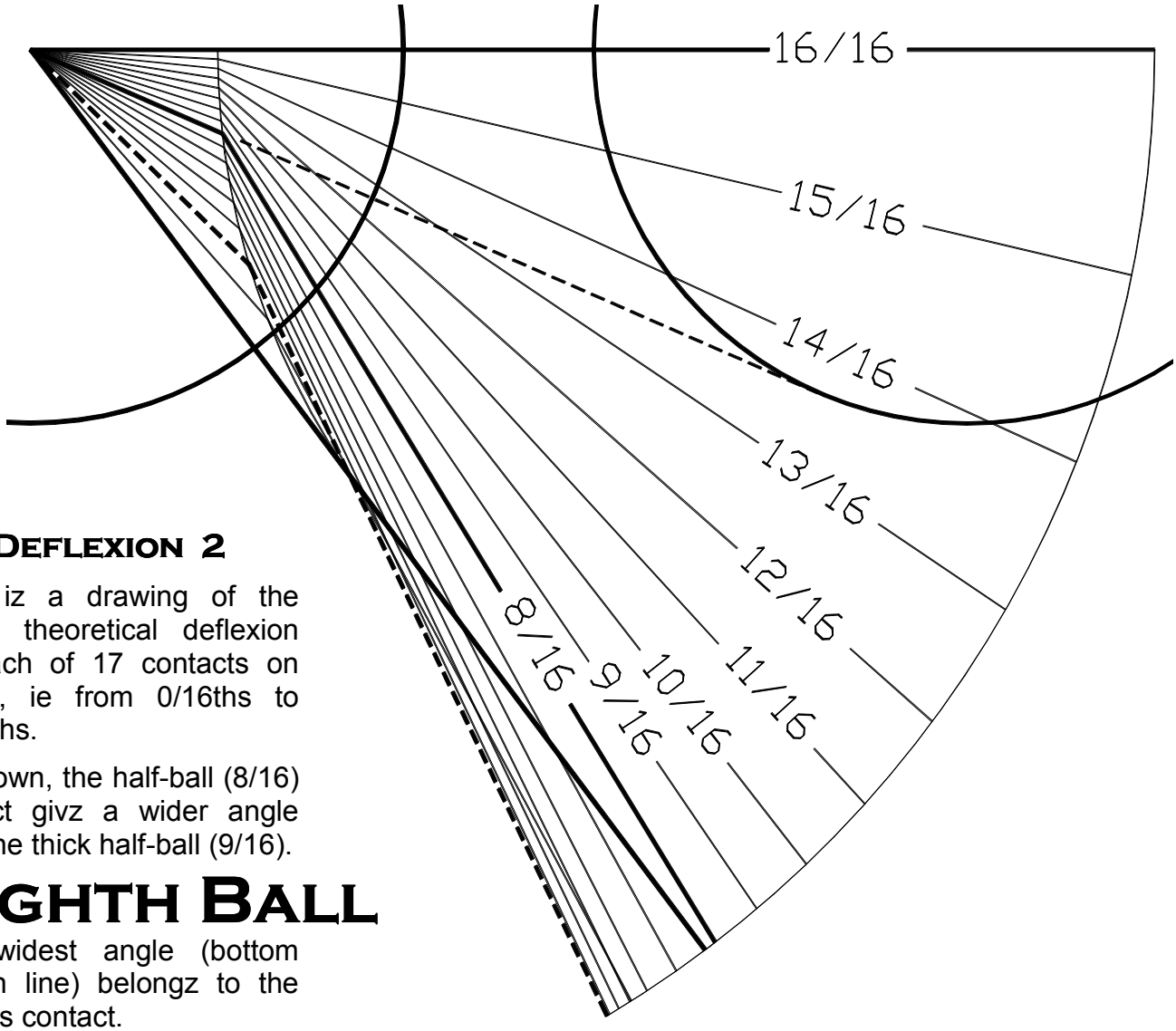


## Deflexion 1

Here the qball iz a ¼ ball from the yellow, we want to play a simple cannon. We know that we should try to contact the red az thinly az possible, to leev the friendlyst angle we ken for our next cannon. The question iz.....

## Which Aim on Yellow givz the Widest Angle??

Here we arnt interested in a swerve shot or a mini-masse', & we don't want to uze any side-spin. We are going to simply roll the qball with no side-spin. So, where should we aim?? Now, most playerz would elect to aim a thick half-ball on yellow (9/16ths) -- koz they think that this givz them the widest deflection angle for their loozer game (ie for long-range loozerz). But, this iz not the correct answer -- the contact giving the widest deflexion-angle for this short-range cannon iz 2/16ths. Hard to beleev, iznt it ??



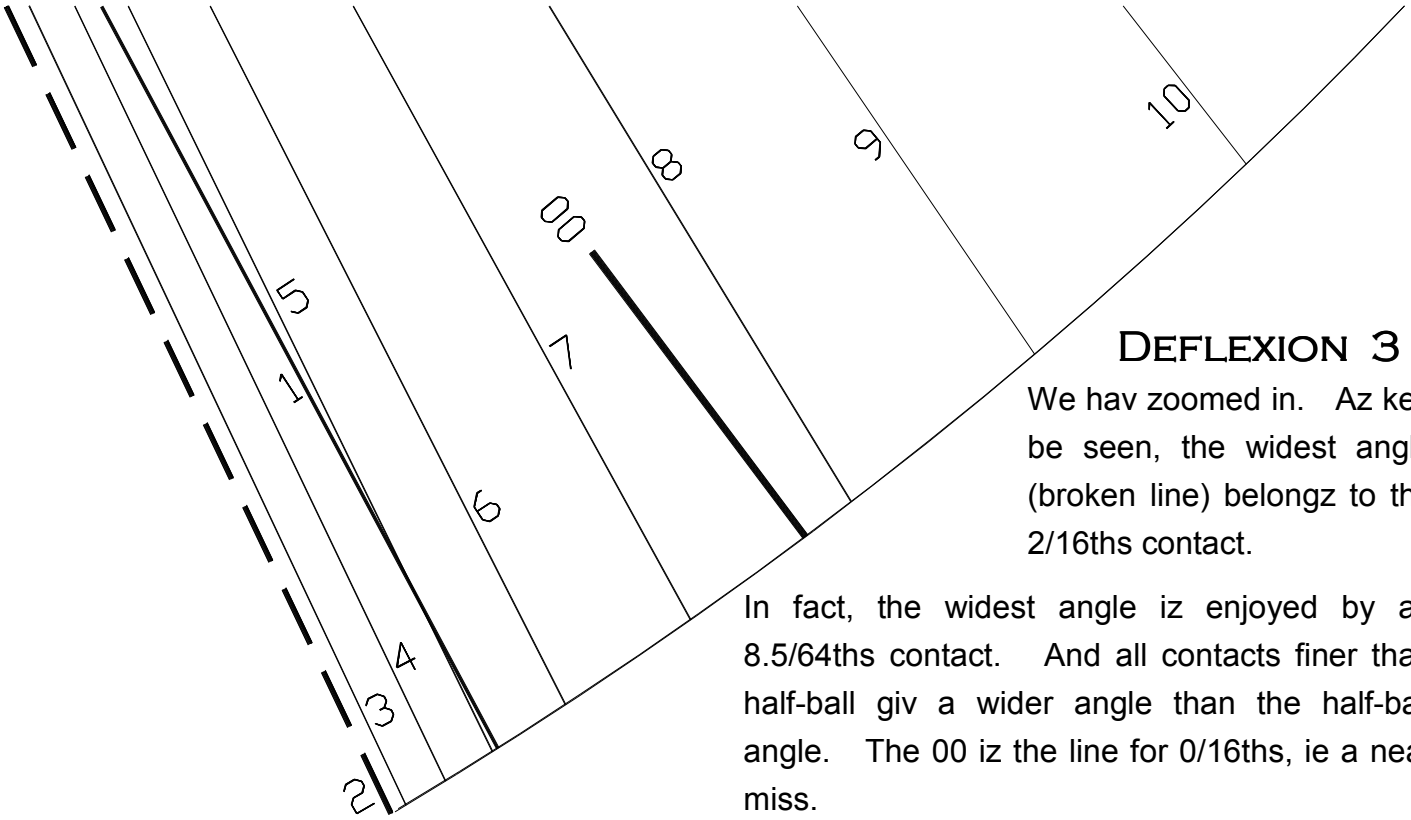

### Deflexion 2

Here iz a drawing of the qball'z theoretical deflexion for each of 17 contacts on yellow, ie from 0/16ths to 16/16ths.

Az shown, the half-ball (8/16) contact givz a wider angle than the thick half-ball (9/16).

## Eighth Ball

The widest angle (bottom broken line) belongz to the 2/16ths contact.




## Deflexion 3

We hav zoomed in. Az ken be seen, the widest angle (broken line) belongz to the 2/16ths contact.

In fact, the widest angle iz enjoyed by an 8.5/64ths contact. And all contacts finer than half-ball giv a wider angle than the half-ball angle. The 00 iz the line for 0/16ths, ie a near miss.

This must be hard to believe for a dyed-in-the-wool loozerer. She thinks that the largest deviation angle iz the thick half-ball, & that all other contacts giv a thinner deviation angle. This might be correct, depending on how u define deviation angle. It's nearly all xplained in the following section called Maximum Deflexion Angle. The following xtract iz interesting.

*I know that up to now we hav mainly been talking about Maximum Deflexion Anglez, but the anglez are of little interest. What are of interest are the Maximum Deflexion Contacts giving the Maximum Deflexion Anglez.*

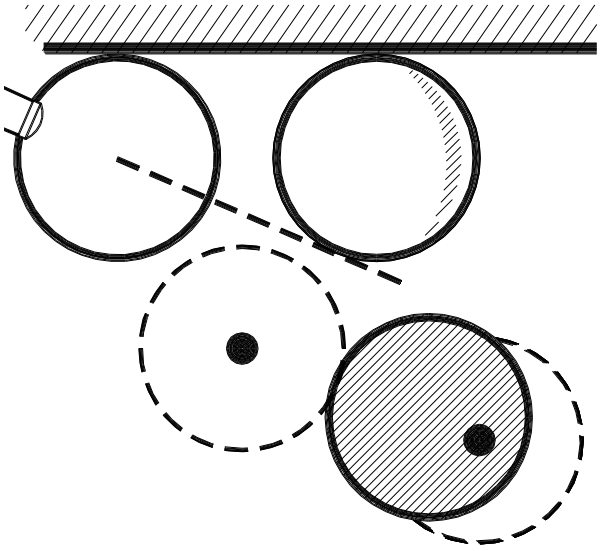
*When u aim u aim for a contact, eg half-ball, it iz the contact that iz meeningful to a player. The Maximum Deflexion Contacts were az followz.*

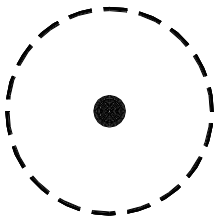
| *Range to third ball* | *Zero* | *½ ball* | *1 ball* | *2 ball* | *4m* |
|---|---|---|---|---|---|
| *Separation ¼ ball* | *8/64* | *8.9/64* | *9.5/64* | *10/64* | *11/64* |
| *Separation ½ ball* | *10/64* | *12.6/64* | *16.9/64* | *19/64* | *21/64* |
| *Separation 1 ball* | *12/64* | *20.9/64* | *22/64* | *23/64* | *24/64* |
| *Separation 2 ball* | *16/64* | *22.8/64* | *24.3/64* | *25.2/64* | *27/64* |
| *Separation 4 ball* | *20/64* | *24/64* | *25.6/64* | *26.7/64* | *29/64* |

*Az carn't be seen, when the separation between qball & yellow iz not large, the old red-ball player'z thick half-ball iz worse than useless. A thick half-ball would be getting a lot less Deflexion Angle, not more. None of the above contacts giving maximum Deflexion Angle came within a bull'z roar of 32/64 (half-ball), not even for a range of 4000mm (a large billiard table iz only 3600mm long).*

*For a separation (distance between qball & yellow) of a ½ ball & a range (distance between yellow & red) of ½ a ball, which would be commonplace in a run of nursery cannonz, the maximum Deflexion Angle iz obtained with a 12.6/64 contact, which iz below a quarter-ball (16/64), & milez below a half-ball (32/64).*

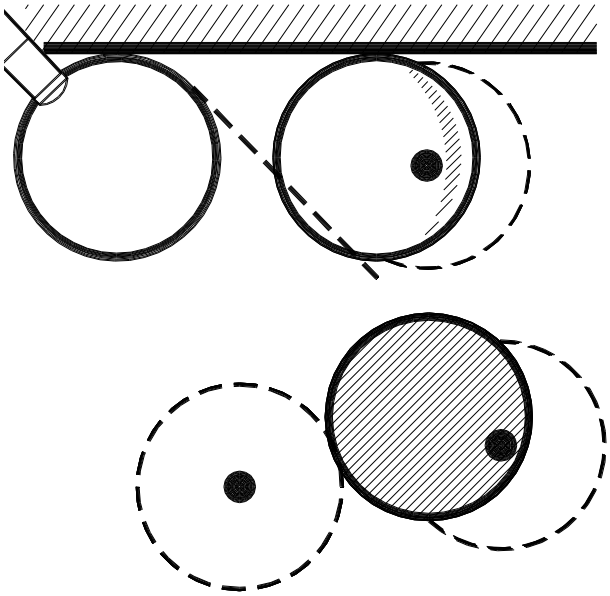
# Which Aim givz Widest





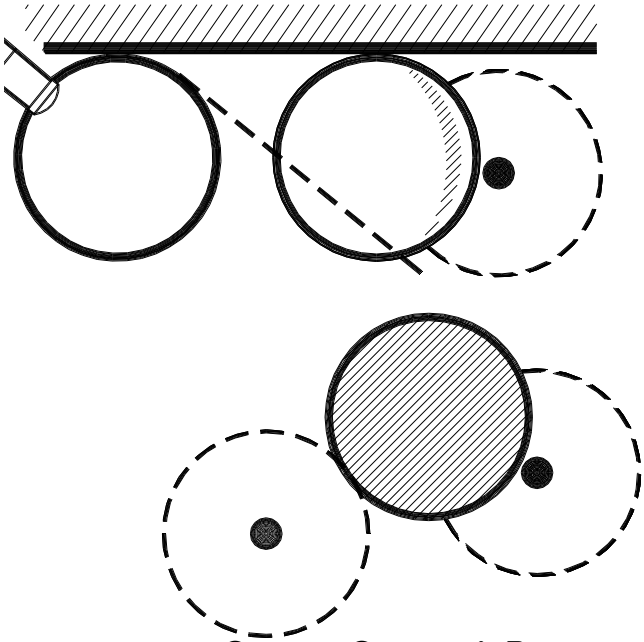
## Deflexion 4
## Half-Ball

Here iz what happenz in Deflexion 1 when we hit the yellow half-ball (32/64). The leev iz very bad (broken ballz). The leev for a thick half-ball (say 36/64) would hav been even worse.



## Deflexion 5
## Eighth-Ball

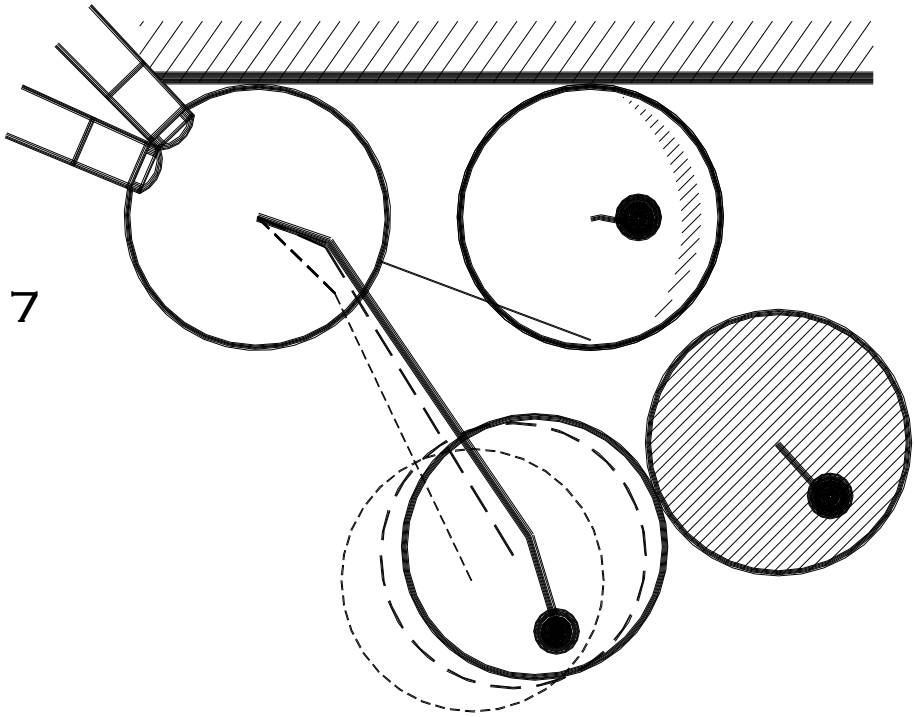
Here we hav hit the yellow an eighth ball (8/64ths), ie the contact giving the maximum deflexion-angle. The leev iz ok-ish. (Actually, according to the chart, between 8/64 & 8.9/64 givz the maximum).



## Deflexion 6
## Quarter-Ball

But (az shown) the best rezult & leev iz gotten by hitting the yellow a quarter-ball (16/64) az shown. A quarter-ball duznt giv the widest deflexion-angle, but, in this instance, it more than makes up for this by bumping the yellow to good pozzy, further east. Nothing'z ever simple, iz it. Funny stuff for us red-ball playerz. Close cannonz are a new world, we have a lot to unlearn (look for this line when the film kumz out). In reality, here in 6, u might uze some swerv, & get an even'better pozzy (not shown). Aim would be say a thick-quarter-ball & (after the swerv) the contact might be say a thin-quarter-ball.

# Which Aim givz Narrowest



Deflexion 7

**Short-Sighted** And this deflexion-angle paradox ken work the other way. Here, in 7, we need a narrow deflexion-angle to score the cannon.

**Thick ½ Ball** Az shown the cannon iz possible if we hit the yellow a thick half-ball. The qball contacts the red az shown by the solid ball. Here, for simplicity, we ignore the fact that the red iz actually bumped out a little by the yellow before the cannon iz made.

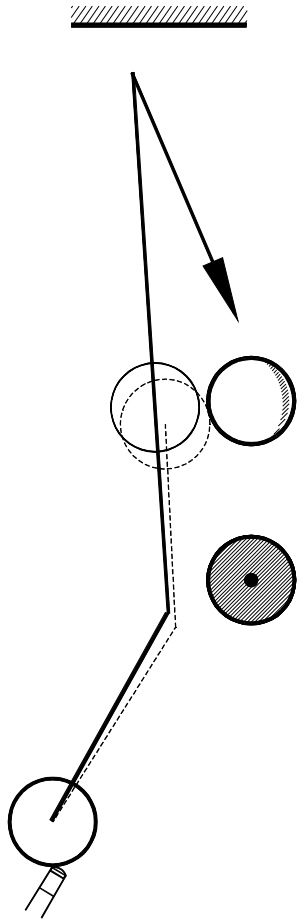
**Half Ball** The first broken ball showz the rezult of hitting the yellow half-ball. Az shown, the qball would miss the red.

**Quarter Ball** The dotty ball showz the rezult of hitting the yellow a quarter-ball. Az shown the qball would miss the red by a mile.

**Optical Illuzion** Most playerz would feel that a thick half-ball would hav no chance of making the cannon. This iz an optical illuzion stemming from yearz of playing medium-range & long-range loozerz. We all judge deflection anglez from the outside of the yellow, but in fact the qball alwayz starts its journey from a point inside the yellow, uzually well inside. Even for the thinnest contacts, the qball starts its journey inside the edge of the yellow.

**Short Sighted** There iz one more effect happening here. Koz of the close-range, the aim moovz further around a large amount for each 1/16$^{th}$ increment of contact. The deviation angle for each 1/16$^{th}$ increment of contact iz the same anywhere on the table, & for all rangez. But, when u compare one contact with another u havta add (or subtract) the extra angle due to the different line of aim. At longer rangez it makes little difference, but at very short-range it makes all the difference. See what i meen ?? Geza Gazdag would say that the qball iz short-sighted. This kumz in usefull when playing ThickAlongz. Anyhow, this stuff iz explained in the following section on Maximum Deflexion Angle.

# ReLoading Yellow



**Deflexion 8A** Here we hav a promising floating-yellow pozzy. Mike & Robby & Mathew & David & Joe might play a cushion-cannon with right-hand-side (az shown) to bump the yellow closer to the spot to ***re-load*** the yellow. But if uken see too much of the yellow then this stroke iz risky, u might ***accidentally touch*** the yellow on the way past (not shown), in which case the *q*ball might stop just west of the yellow (not shown), giving a ***cover*** for the pot-red.

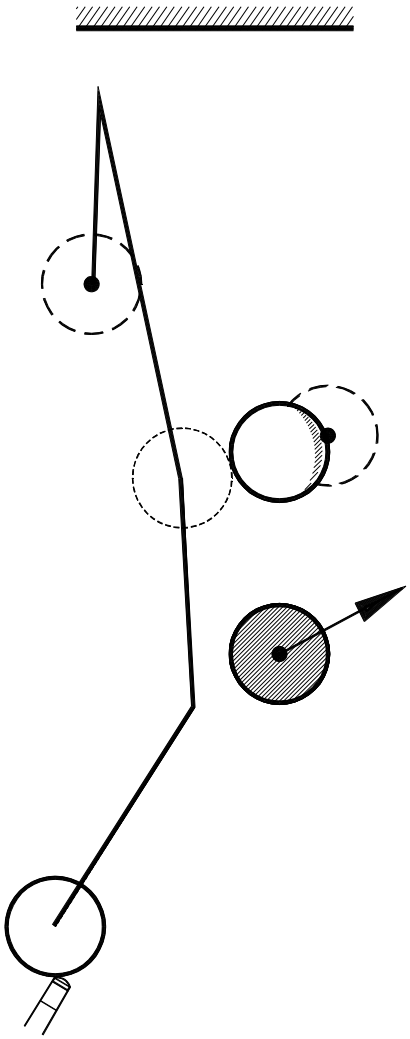
## Run-Throo

If u are worryd about the accidental touch on yellow, u might play a thick run-throo red (not shown), landing softly full on yellow, & wait for a better pozzy to re-load the yellow later.

## Thick Half-Ball

U decide to try the cushion cannon, to re-load the yellow. Being a red-ball player, u are tempted to aim a ***thick half-ball*** on red, to make sure u ***don't*** touch yellow on the way past. But, a thick half-ball will actually make sure u ***touch*** the silly looking yellow --- this iz shown by the broken line & broken ball.

## Maximum Angle



Koz, in the pozzy shown in 8A, the maximum deflexion-angle iz gotten from a ***3/8th*** contact on red --- shown by the solid line & solid ball. Hardta believe iznt it ??

# Best Stroke

**Deflexion 8B** The best shot iz to play thick half-ball on red, not too hard, to push the yellow a little east az shown. This eastern pozzy iz better for a big floating-yellow break --- & its better for a ***nursery-gather*** too. Hmmmm. While we are uzing Krapamith --- better uze ***check-side***.

**Mac** Clark McConachy launched this form of floating-white on the public in 1929, ie with the white a bit (or a lot) east of the spot. He called it a moovment of 10.

**Murt** Somehow Murt thort that Murt invented this sort of pozzy, & the moovment-of-ten. Not so, unless it woz Murt who showed it to Macka. Hmmmmmmmm.

# Maximum Deflexion Anglz

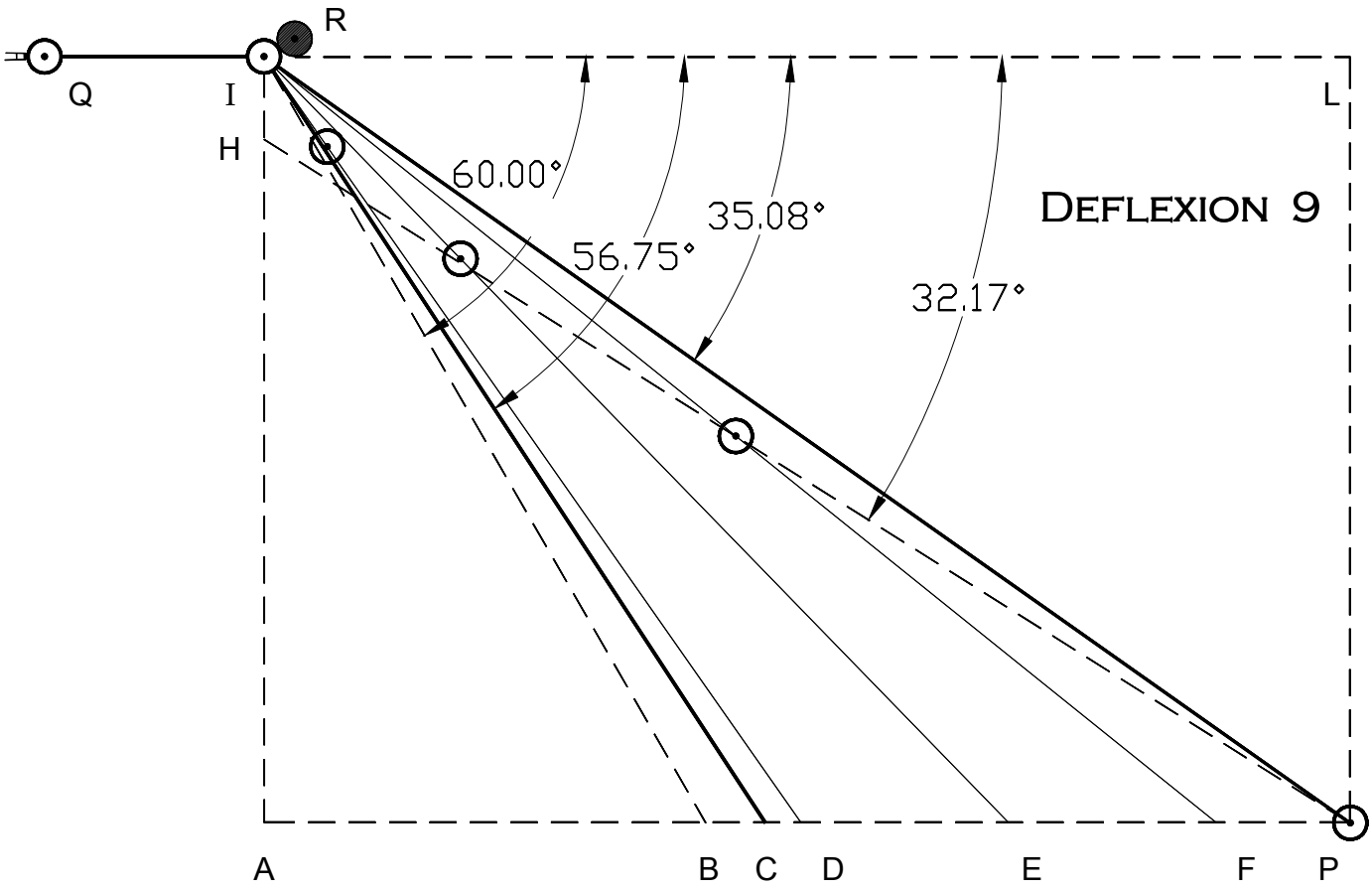
The ***half-ball*** angle iz the ***foundation*** of English billiardz, it iz near'nuff the ***maximum*** angle taken by the cueball after it hits the red ball. And red-ball playerz love the friendly ***margin-for-error*** they get with half-ball loozerz. But ***nursery*** cannon playerz know that the half-ball contact ***never*** givz the ***widest*** angle when playing nursery cannonz, a ***thin*** contact alwayz givz the maximum, sometimez thinner than ***quarter-ball***. Nothing haz ever been written on this subject. Perhaps ***Wally*** knew about it but kept it quiet. Anyhow, i decided to do me own ***theoretical*** calculationz.

## Our Deviation Angle (1)

Ok --- the first thing we do iz introduce (again) the term that i call ***deviation angle***. In the chapter ***Center Spot Loozerz***, in ***Billiardz Arithmetically Treated,*** i sed that the deviation angle woz .....

***(DA1) .....the change in the direction of travel of the qball after it hits the objectball.***

This definition (which i here call DA1) uzez nice simple wordage, but it iz allso very loose. It ken meen lots of thingz. Some of theze lots of thingz kenbeseen in the following depiktion of a half-ball loozer off the red into the ryht-top-pocket (the red sitting on the center spot --- the pocket iz at P).




We show the *q*ball at impakt (I) & then at 4 more spots (DEFP) along the way --- P iz at the corner pocket. The *q*ball (F) shown sitting on line I F iz at the point where skidding haz stopped --- ie after which the travel iz a straight line --- & befor which the travel iz suppozedly a parabola. The

*q*ball'z initial line of travel iz Q I L. The *q*ball'z final line of travel (at the pocket) iz H P, but for the purposez of mezuring our deviation angle we say that the overall deviation (at the pocket) iz actually best reprezented by the line I P.

Hence the final deviation angle, when the *q*ball iz at the pocket, iz we say the angle between Q I L & I P (ie angle L-I-P). I mezured this to be 35.078° --- this woz for a medium paced loozer, ie the sort u often play with yellow on the center spot & *q*ball in hand, hitting hard enuff for the yellow to kum around to a middle pocket off 3 cushionz. This deviation angle inkreecez az the speed of impakt inkreecez. It allso inkreecez if u mezure it at earlyr points along the *q*ball'z travel.

But the maximum deviation angle iz gotten just az the *q*ball parts company with the red. The line of travel at the end of impakt iz I C --- this iz 56.75° --- this iz 3.25° less than the 60° assumed by skoolkidz & shown here by the line I B.

Hence our long-loozer enjoyz an infinite number of deviation anglez between 56.75° & 35.078°.

# Hemming'z Deviation Angle (2)

George Wirgman Hemming haz a chapter on the in-off angle in hiz book Billiardz Arithmetically Treated dated 1899. Hemming derivez som equationz for the anglez taken for varyus contacts, & inferz that –

> ..... if the ballz were perfiktly elastik, the maximum deviation would be 33 degrees 45 minutes (this being the final angle of travel, ie neglecting the parabolic first part of the qball'z journey).
>
> ..... this would occur slightly fuller than half-ball, ie at an angle of 28 degrees 7 minutes 30 secondz ( ie 1 degree 52 minutes and 30 secondz fuller than half-ball which is 30° ie it is 0.5286 of full-ball).

Hemming haz a lot of good stuff, but i hav trouble following much of hiz article.

- Hiz analysis iz basically theoretical, but he duz mention investigationz, trialz, experimental strokes etc. Hemming sez.....

> *....." The result of a long series of experiments, which i think may be depended on within the limits stated below, gives me for the value of $\delta$, when $\theta = 30°$ (ie in effect for the maximum value of $\delta$), something between 33°40' & 33° 45'.*

- In one place he sez that for practical rezults one needz to estimate *e* , and he sez that...

> *" For good ivory e may be taken to be about 1/15, according to results obtained from investigations independent of the billiard table"* .....(*but then he doesn't uze it*).

- He sez that .....

> *"We know, as a matter of fact, that any change in the value of e, say from 1/15 to 1/30, will make a marked change in the value of* $\delta$ (meaning deviation angle) *and subsequent investigations will show that this may exceed a degree and a half "* ...
>
> (*ok i gess*).

- And he sez *(f)* , the friktion between ballz, iz no more than 1/100 (for ivoryz), & may be neglected.....

.(frayed knot, it's about 1/20 for bakelitish modern ballz, & not much less for ivoryz).

- He sez that hiz deviation angle (the angle of travel after pure rolling exists) iz independent of velocity.....(frayed knot, read my article called Stun Throo ).

- He sez that by playing similar strokes on a fine cloth and on a much coarser cloth we can get large varyationz in the obzerved valuez of deviation angle .....

(frayed knot, it's not possible, not by hiz definition of deviation angle, koz changing friktion or roll rezistance etc wouldn't change hiz deviation angle, my deviation angle would change but not hiz).

- He also sez .....

*" it is further observed that by increasing the coarseness of the cloth the maximum value of* $\delta$ (deviation angle) *may be increased by two or three degrees, as a few trials without any minute measurements seemed to me to show "*.....
(ditto my earlyr comments).

Anyhow, it appearz that Hemming'z definition of deviation angle kenbe written az followz.....

**(DA2) .....the final angle of travel, ie neglecting the parabolic first part of the qball'z journey.**

This final angle of travel iz shown by the broken line H P, in Deflexion 9, & i estimate that this angle iz say 32.17° --- hence this would be Hemming'z deviation angle for Krapamith ballz. Hmmmmmm. It seemz to me that if i had uzed ivoryz for my tests then Hemming'z deviation angle would hav been perhaps say only 30° --- which iz much short of Hemming'z 33° 45'. Hmmmmm. Whats going on here ??????????? I think that Hemming forgot hiz own definition (DA2), & ended up uzing my definition (DA1) --- the difference being about 3°, or even much more than 3° if on a new slippery cloth.

# Our Deviation Angle (3)

Hemming'z deviation angle (DA2) iz actually just one particular sub-definition of (DA1). I want to make (DA1) more specifyk by re-wording it az followz.....

***(DA3) ..... the change in the direction of travel of the qball after it hits the objectball, AFTER being a straight line drawn from the center of the qball at impakt to the center at any specifyd time.***

Hence we now havta specify a set of circumstancez each time we mention deviation angle. To nail it down properly, we need to know the 3 pozzyz of the *q*ball, ie at start, at impakt, & at target. And we need to reference this to the speed of impakt, ie very soft ..... to very hard. And a few other thingz --- like how new & slippery the cloth iz --- & what sort of ballz (Bonzoline or Krapamith or Ivory etc). I suppoze that u could allso mention sidespin & skrew & stun etc allso --- but in this chapter we of course only deal with pure rolling (ie befor impakt --- i think).

If (DA3) iz your definition of deviation angle, then it's perfiktly ok to say that a thick half-ball contact alwayz givz u the maximum deviation angle, ie for all separationz & rangez. But, this definition, az good & usefull az it iz, duznt giv me all of the answerz to all of my nursery questionz. I need another definition --- az followz.....

# Our Deviation Angle (4)

A more usefull definition of deviation angle for close-cannonz would be az followz.....

***(DA4) ..... the change in the direction of travel of the qball after it hits the objectball,***
***.....AFTER being a straight line drawn from the center of the qball at impakt to the center at any specifyd time,***
***.....BEFOR being a straight line drawn from the center of the qball befor impakt to the center of the red.***

Hence, in this definition (DA4) u havta add the additional little angle R-Q-I to (DA3).

This additional little angle iz only say 1.37° for a half-ball long-loozer off red on the center spot from in-hand. But it inkreecez to 30.00° (from simple geometry) az u bring the *q*ball up to touch the red. At a separation (ie the clear gap, ie the daylite) of say a half-ball between the *q*ball & red, the xtra angle for a half-ball contact iz 19.47° (from simple geometry).

Hence, at nursery cannon separationz, the half-ball deviation angle (DA4) iz no longer say 35°, it iz more like 55°.

Az i might hav allready sed, it makes little difference which definition (DA1 or 2 or 3 or 4) u are uzing or thinking or seeing or looking for, when the qball & red (the first object-ball) are separated a long distance. But with small separationz this ***little angle*** (R-Q-I) bekumz a very big angle.

Now, the problem iz that when a red-ball player wants the largest deviation angle possible (without uzing pace swerve or side) she will alwayz automatically aim for a thick half-ball, at any & all separationz & rangez. She duznt realize that the best rezult (the widest angle) at small separationz iz got with a contact less than half-ball, & for very small separationz the widest angle iz got with a contact less than a quarter-ball. Such deluzionz ken stuff'ya'up in close cannonz (nursery cannonz) & even in top of the table play.

It would be nice to have a different term for each form of deviation angle. I think that the third definition (DA3) fits that term (deviation angle) best. So we need a new name for the fourth definition (DA4). What to call it ?? How about.... .***Deflexion Angle***. But i gess that u allready saw the main title for this chapter.

I allready mentioned that a red-ball player iz in luv with a thick-half-ball contact. The problem iz that her eyez hav long ago decided on their (or its) own definition for deviation angle. And that iz what we look at next.

# Player'z Deviation Angle (5)

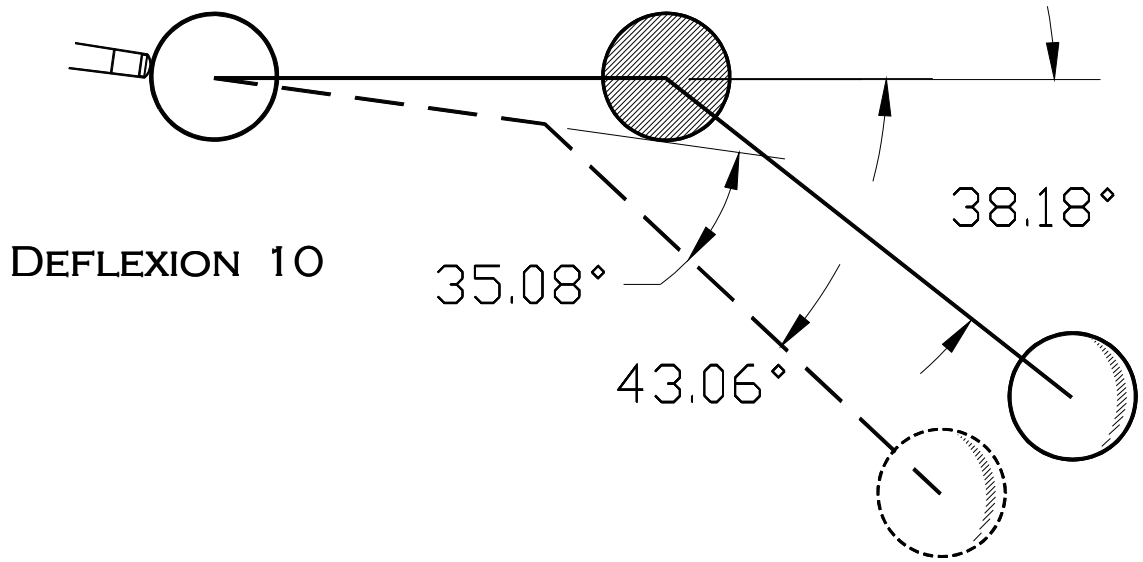
When a red-ball player gets down on a long-cannon, she seez the 3 ballz. Her eyez are more familiar with the needed angle or contact etc for their favorit separation between the *q*ball

& red, & for their favorit range between the red & the yellow. Theze will probably be for her old familiar long-loozer off the center spot with *q*ball in-hand --- this shot being near'nuff the one taking up more of her praktis hourz than any other.

Every other separation & range & angle iz gauged from the familiar favorit half-ball long-loozer. Change the separation, or change the range, or both --- or change the red to a yellow or white --- or place the third ball in the field of view, & she iz immediately uncomfortable. I could add to this --- or change from the small (puke) Krapamiths to the nice big old Bonzolinez.

Or change the target from the old familiar corner pocket --- ie make the target the third ball (ie the red or yellow or white) --- & she iz probably even more uncomfortable.

The trouble is that the eyez hav their own silly little natural verzion of the deviation angle. I will call this (DA5). The eyez see 3 ballz (or 2 ballz & a pocket) --- hence (DA5) iz naturally based on the anglez formed by the centerz of the 3 ballz. More than that, (DA5) iz naturally based on the 3 ballz sitting in thoze old familiar favorit pozzyz. Hence, (DA5) in Deflexion 9 iz the angle Q-R-P, which happenz to be about 38°. Deflexion 10 showz what i meen.




***(DA5) ..... With the 3 ballz in this (or any) pozzy, her eyez karnt help drawing a line from the center of the qball to the center of the red to the center of the yellow (which in 10 iz drawn to form her favorit center spot long-loozer angle, ie 38° ). This sort of center-to-center deviation angle iz what i call (DA5).***

But in 10, when she hits the red half-ball, the *q*ball'z 35° deviation angle will take it wide of the yellow, az shown by the broken yellow (i assume here that we are talking about a soft shot, with allmost zero kurv after impakt, & i assume that the 35° holdz good at all speedz). The 38° angle in 10 iz az i allready sed the long-loozer angle Q-R-P in Deflexion 9.

U see lots of such misjudgments all over the table in matchplay. This sort of stuff-up bekumz more prevalent az the *q*ball gets closer to the red (ie the first ball).

Anyhow, (DA4) iz allmost useless for any scientific mezurement of deviation anglez & contacts --- it relyz too much on the exact placingz of all 3 ballz. (DA3) iz what i uze. So nextly we will do lots of mezuring uzing real ballz on a real table. But befor we look at that, we will look briefly at some of the termz surrounding this whole bizzness --- uken skip theze if u want.

# Anglez & Contacts

There are lots of anglez & contacts that we could talk about in a billiard ball impact, which i don't really want to koz thingz get complicated enuff az it iz, but perhaps it will help to hav a good squiz at the territory. There are no standard namez for anglez etc, anyone ken uze any name they wish. I looked at deviation angle, deflection angle, deflexion angle, divergence angle, diverzion angle etc. The following anglez contacts & namez might kum up.

***Separation*** the distance between the qball & the first object-ball.

***Range*** the distance that the qball needz to travel to reach the second object-ball after hitting the first object-ball.

***The contact angle*** thiz iz the angle of the line joining the center of the qball & the center of the object-ball during impact, the angle being mezured from the pre-impact line of travel of the qball.

***The initial contact angle*** when the qball first touchez the stationary object-ball, which for a half-ball aim would be 30°.

***The final contact angle*** when the qball last touchez the object-ball, which for a half-ball aim could be say 31°, the object-ball at this time having its maximum velocity.

***The average contact angle*** the ave of the initial & final contact anglez, which for the above half-ball contact would be 30.5°.

***The effective contact angle*** this iz possibly the same az the average contact angle, it iz the angle the object-ball would travel at if there were no ball-to-ball friktion.

***The deviation angle*** being the angle between the qball'z pre-impakt & post-impakt lines of travel. Earlyr we mentioned 5 types of deviation angle.

***The initial deviation angle*** the deviation angle at the instant that impact endz. It iz the largest deviation angle for that particular impact event, ie before initial swerv starts. For the above half-ball contact it would potentially be 59.5°, but in fact it would be say 56.75° due to the fact that impacts are not Perfiktly Elastic.

***Perfiktly Elastic*** I apologize for uzing this silly name --- unfortunately it haz found widespread use & no doubt it haz allready led to many stuff-ups. Teacherz tell skoolkidz that if an impact iz perfiktly elastik there iz zero energy loss --- which iz ok. But it creates a false pikture in a kid'z mind. Imagin a ball bouncing off a wall --- befor it hits the wall the ball iz floating happyly throo the air, all of its musclz are very still & relaxed. After it bouncez off, the ball'z length & width are changing continuously, & not necessaryly in phaze --- its musclz are anything but still & relaxed --- there iz lots of momentum trapped in this ringing. And, no matter how elastik a ball etc might be --- uken never eliminate som of such ringing --- even if the ball iz perfiktly elastik. Or put another way --- u might be able to make a ball that iz nearly perfiktly elastik, but u will never get very close to making an impakt that iz nearly perfiktly elastik --- hence the use of the word elastik iz bad for bizzness, the bizzness of teaching kidz. Why not uze termz like Koefficient of Impakt ( **OO** ), & Komposit Koefficient of Impakt ( **O•** ), & Koefficient of Ball-Bounce (**O‖** ).

***The final deviation angle*** the deviation angle the qball would hav if it never stopped, ie at infinity, or more simply the line of travel of the qball after skidding stops ie after the initial swerve endz. This iz Hemming'z deviation angle.

***The aim angle*** the angle between the aim-line (the pre-impact line of travel of the qball) & the ball-to-ball-line ( the line joining the centerz of qball & object-ball before the shot). The aim angle iz fixed for any one impact. It will be larger for wider contacts on the red, & larger when the qball iz closer to the object-ball, it iz zero when aiming full-ball on the object-ball.

***The Deflexion Angle*** the Deviation Angle plus Aim Angle. It uzually dekreeces az the range inkreecez, if the *q*ball haz topspin.

***The Maximum Deflexion Contact*** the contact on red that will giv the largest Deflexion Angle uken get for the shot facing you. It iz alwayz (xcept for xtreme forcerz) in the range zero to a thick half-ball, ie 0/64ths to say 35/64ths. Az uzual we are ignoring screw & side, & the extra width u get if u belt the ball really really hard.

***The Maximum Deflexion Angle*** the Deflexion Angle u get when the contact iz the maximum deflexion contact.

# Deviation Anglz

The next problem iz that we havtahav some sort of accurate deviation anglez to start with, to help calculate the theoretical Deflexion Anglez.

**SkoolBoy** We could do a skoolboy type of analysis. We could calculate theoretical deviation anglez uzing conservation of whatever uzing zero lossez or whatever, ie zero impact loss, zero friktion loss, zero skidding friktion loss, zero curve, zero swerve.

**Arithmetically Treated** Actually, i reckon that our skoolkid would hav mission impossible. That's why i am doing it the eezy&accurate way, the Billiardz Arithmetically Treated way.

**Center-Spot Loozerz** Anyhow, i already have my old deviation angle rezults that i mentioned earlyr, for center-spot loozerz, so the eezy way out iz to uze theze rezults. The Deflexion Anglez are only going to be for soft shots, so i reckon my deviation anglez will be ok. They wouldn't be any good for high-speed short-range shots, they would under-estimate the curved contributionz. But, at slow speed, i reckon that the curved bits i had for the long loozerz would be near'nuff in proportion to the curved bits uget for soft shots.

I could add that the deviation anglz for slowish shots would be larger koz the stun-throo iz less %wize than at the higher speedz that i uzed in the center-spot tests (stun-throo iz the qballz speed after a stun-impact, ie when the qball haz no initial topspin, it iz about 1% at nursery cannon speedz & about 3% at center-spot loozer speedz).

And larger koz the ball-to-ball friktion (slippage actually) lossez at low speed are larger due to the larger impact timez.

*This iz complicated, but it iz the topspin energy that sufferz most, hence a larger deviation angle, the ball-to-ball slippage energy loss at nursery cannon speedz iz about 5% of total pre-impact energy & at center-spot loozer speedz it iz about 2%, i alwayz try to uze momentum for all my calculationz & rarely havta uze energy but here i had no choice*.

**NapKurv** But, az we are mainly talking about cannonz on the top-cushion, the deviation angle would also be diminished, diminished by the nap-curve due to the induced right-hand-side (ballz travelling against the nap curve left if having right-hand-side). And diminished due to the larger %wize Janus'Cloth'Effect.

**Janus Cloth Effect** When there iz no nap, & when there iz nap, the Janus Cloth Effect tryz to make the ball curve left if having right-hand-side, due to the changing footprint shape etc az the ball slowz, this & the earlyr stuff are all fully xplained in Billiardz Arithmetically Treated, & mentioned in Chapter 65 (DriftKurv).

In any case, whether larger or smaller, the deviation anglz would all be larger or smaller in ruffly the same proportionz (i almost sed degree), so it duznt make much difference. I am happy to uze my center-spot rezults.

# Center Spot Loozerz

The deviation anglez i am gonna uze are the onez i mezured for loozerz off the center spot, az followz. The first column iz the contact in 64ths (16 iz quarter-ball). In the second column 0.25 iz quarter-ball. The third column iz the deviation angle (degreez).

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 64 | 1.00000 | 0.000 | 42 | 0.65625 | 33.996 | 20 | 0.31250 | 30.592 |
| 63 | 0.98438 | 2.931 | 41 | 0.64063 | 34.367 | 19 | 0.29688 | 29.870 |
| 62 | 0.96875 | 5.533 | 40 | 0.62500 | 34.667 | 18 | 0.28125 | 29.119 |
| 61 | 0.95313 | 8.033 | 39 | 0.60938 | 34.902 | 17 | 0.26563 | 28.345 |
| 60 | 0.93750 | 10.426 | 38 | 0.59375 | 35.076 | 16 | 0.25000 | 27.552 |
| 59 | 0.92188 | 12.707 | 37 | 0.57813 | 35.194 | 15 | 0.23438 | 26.745 |
| 58 | 0.90625 | 14.874 | 36 | 0.56250 | 35.260 | 14 | 0.21875 | 25.921 |
| 57 | 0.89063 | 16.922 | 35 | 0.54688 | 35.278 | 13 | 0.20313 | 25.077 |
| 56 | 0.87500 | 18.850 | 34 | 0.53125 | 35.252 | 12 | 0.18750 | 24.204 |
| 55 | 0.85938 | 20.658 | 33 | 0.51563 | 35.184 | 11 | 0.17188 | 23.289 |
| 54 | 0.84375 | 22.345 | 32 | 0.50000 | 35.078 | 10 | 0.15625 | 22.314 |
| 53 | 0.82813 | 23.912 | 31 | 0.48438 | 34.864 | 9 | 0.14063 | 21.253 |
| 52 | 0.81250 | 25.361 | 30 | 0.46875 | 34.771 | 8 | 0.12500 | 20.076 |
| 51 | 0.79688 | 26.693 | 29 | 0.45313 | 34.639 | 7 | 0.10938 | 18.744 |
| 50 | 0.78125 | 27.911 | 28 | 0.43750 | 34.453 | 6 | 0.09375 | 17.210 |
| 49 | 0.76563 | 29.018 | 27 | 0.42188 | 34.203 | 5 | 0.07813 | 15.419 |
| 48 | 0.75000 | 30.018 | 26 | 0.40625 | 33.884 | 4 | 0.06250 | 13.306 |
| 47 | 0.73438 | 30.914 | 25 | 0.39063 | 33.493 | 3 | 0.04688 | 10.798 |
| 46 | 0.71875 | 31.711 | 24 | 0.37500 | 33.032 | 2 | 0.03125 | 7.810 |
| 45 | 0.70313 | 32.412 | 23 | 0.35938 | 32.505 | 1 | 0.01563 | 4.246 |
| 44 | 0.68750 | 33.024 | 22 | 0.34375 | 31.918 | 0 | 0.00000 | 0.000 |
| 43 | 0.67188 | 33.550 | 21 | 0.32813 | 31.278 | | | |

# Calculation of Deflexion

## Drawingz

The eezyst & most accurate way to do the calculationz woz to do accurate drawingz of the two ballz (the qball & the red), showing the qball trajectory before & after hitting the red.

## Trajectoryz

I did a trajectory for each 1/64th contact. To save time, i woz able to get away with doing only say 10 trajectory'z (instead of 64) for each drawing. So it's just simple geometry really.

When i sed the eezyst way, i should have sed the only way -- i karnt imagine anyone having the time to set up some sort of computer program to do any of this properly -- uwill see what i meen.

**Separationz** I did five drawingz, uzing AutoCAD (which duz very accurate drawingz). One with the qball attacking the red from a separation of ¼ ball, then from a ½ ball, then from 1 ball, then from 2 ballz, & lastly from 4 ballz.

I woz only interested in the maximum trajectory for each of the five casez, so this made thingz eezyr. But not az eezy az u might think. Koz, there'z one more little problem with Deflexion Anglez.

**Range** The maximum Deflexion Angle for any one separation dependz not only on the separation to the red, it also dependz on the range to the yellow. And this iz not koz of the strength of the shot, we all know that strength affects the angle koz of the larger curve. No, the drawingz deal with soft shots with almost zero curve.

**Gainz** It's like this ..... one part of the reazon(z) iz that when u change your aim from say half-ball to say quarter-ball, u immediately gain a few mm of width in your shot due to the new contact point on the red. Know what i meen ?? The size of the gain iz of no real use, but i will giv it here just to emphasis my point. Theze are the gainz uget by re-aiming from half-ball to quarter-ball.

| Separation | ¼ ball | ½ ball | 1 ball | 2 ball |
|---|---|---|---|---|
| Gain | 1.38mm | 2.27mm | 3.35mm | 4.43mm |

**Half Ball** The other part of the reazon(z) iz that contacts less than half-ball alwayz giv a narrower deviation angle. So, let's compare a half-ball trajectory to a quarter-ball trajectory.

**Quarter Ball** The quarter-ball trajectory haz a wider contact on the red, but haz a narrower deviation angle. The half-ball trajectory haz a narrower contact on red, but haz a wider deviation angle.

**Crossing Trajectoryz** Somewhere down the range the two trajectoryz might cross. Whether they cross dependz on the initial separation between the qball & red. For a small (quarter-ball) separation theze two trajectoryz do not cross, but for a two-ball separation they do cross. This meenz that before the crossing-point the quarter-ball contact givz the wider Deflexion Angle, but after the xing point the half-ball contact givz the wider rezult.

**Contacts** So, i drew accurate trajectoryz for each 1/64th contact. Then i inspected the trajectoryz to see which trajectory (and contact) gave the widest Deflexion Anglez at varyus rangez, viz Zero, quarter-ball, half-ball, one ball, two ballz, & four ballz.

**Example** Take a hypothetical example. Say that in one drawing, a 7/64th contact iz the winner at zero range (1mm), & a 12/64th contact iz the winner at long range (4000mm).

**Day in the Sun** U will find that in this drawing 8/64ths, 9/64ths, 10/64ths, & 11/64ths contacts all have their day in the sun, somewhere in between, & in that order.

# Maximum Deflexion Contacts

I know that up to now we hav mainly been talking about Maximum Deflexion Anglez, but now that i hav got the rezults i am not going to givem to you, koz the anglez are of little interest. What are of interest are the Maximum Deflexion Contacts giving the Maximum Deflexion Anglez. When u aim u aim for a contact, eg half-ball, it iz the contact that iz meeningful to a player.

## Contacts

The Maximum Deflexion Contacts were az followz. Theze are partly theoretical, koz they are based on drawingz of the ballz & trajectoryz. But they are also partly empirical, koz the deviation anglez i uzed in the drawingz are based on actual mezurementz (albeit for longer range loozerz hit at medium pace). Here they are, havagoodlook koz a lot of effort & a little thinking went into theze.

| Range to third ball | Zero | ½ ball | 1 ball | 2 ball | 4m |
|---|---|---|---|---|---|
| Separation ¼ ball | 8/64 | 8.9/64 | 9.5/64 | 10/64 | 11/64 |
| Separation ½ ball | 10/64 | 12.6/64 | 16.9/64 | 19/64 | 21/64 |
| Separation 1 ball | 12/64 | 20.9/64 | 22/64 | 23/64 | 24/64 |
| Separation 2 ball | 16/64 | 22.8/64 | 24.3/64 | 25.2/64 | 27/64 |
| Separation 4 ball | 20/64 | 24/64 | 25.6/64 | 26.7/64 | 29/64 |

## Thick Half Ball

Az karnt be seen, when the separation between qball & first object-ball iz not large, the old red-ball player'z thick half-ball iz worse than useless. A thick half-ball would be getting a lot less Deflexion Angle, not more. None of the above contacts giving maximum Deflexion Angle came within a bull'z roar of 32/64 (half-ball), not even for a range of 4000mm (a large billiard table iz only 3600mm long). When i say a range of 4000mm i meen when the trajectory for a soft shot iz extended out to a distance of 4000mm, a real shot would have to be hit hardish to get to 4000mm & so would have a wider initial curve & so a wider Deflexion Angle.

## Quarter Ball

For a separation of a ½ ball & a range of ½ a ball, which would be commonplace in a run of nursery cannonz, the maximum Deflexion Angle iz obtained with a 12.6/64 contact, which iz below a quarter-ball (16/64), & milez below a half-ball (32/64).

## Tricky

Actually, this contact (12.6/64) for this separation (1/2 ball) & this range (1/2 ball), takes the prize for trickyness What i meen iz that if u look at the graph of theze rezults this point iz comparativly lower than all the otherz, it looks like a mistake, but it's not, i triple checked my drawing etc, all the points look lowish but this one iz super-low altho it's not obvious from just looking at the above table.

## Nurseryz

And this (1/2 ball) iz about the separation & range u get most of the time when u are tickling the ballz around at nurseryz. So, ifyawantta maximize the Deflexion Angle aim less than quarter-ball.

# Side-Spin

**Warning** A word of warning about side-spin. Its worth repeating what my other articlez say about side-spin. Side spin duz not affect deviation anglez very much (so Riso Levi got something right after all).

**Check-Side** reducez the deviation angle just a bit, & running-side just a very little bit, both a lot less than what the old red-ball player thinks. Here i am referring to half-ball contacts & contacts not far off half-ball.

Check-side & running-side ken have a substantial effect at contacts much thicker than half-ball, but little at a half-ball & almost zero at quarter-ball (see other articlez).

**Swerv** What the old red-ball player duzn't realize iz that when she playz a long shot with lots of side she uzually gets a lot of swerve (due to the masse' effect of hitting downish) & a lot of curve (due to the effect of the nap), & swerve & curve do not affect deviation angle, but they do affect Deflexion Angle (& i ken add that deviation angle affects Deflexion Angle).

Swerv/Kurve changez the attack angle of the qball onto the red, & hence changez the Deflexion Angle, but it duz nothing to the deviation angle. What this meenz iz that if u want to increase or decrease the Deflexion Angle when playing short range cannonz at nurseryz or at top-of-the-table, its no good relying on side-spin if the contact iz a half-ball or less (it might be ok if the contact iz much thicker than half-ball). So, uhavta raize the butt of the cue & make sure u get some swerve (u won't get any nap-curve at short range).

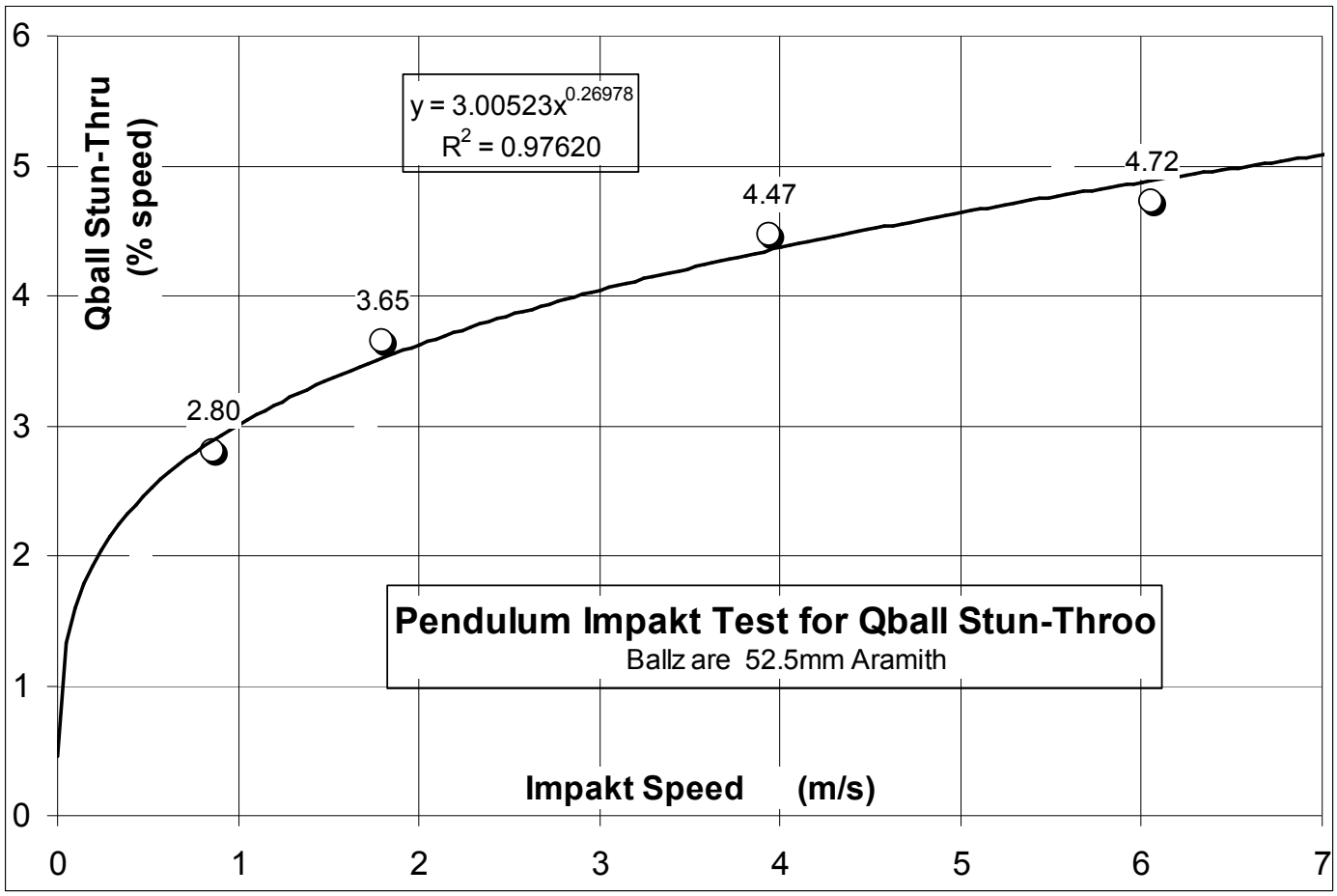
**Short Range Swerv** In fact that iz one good thing about short-range shots, it iz so eezy to get a lot of swerve, softly & reliably. This iz unlike long range shots where u karnt afford to try to get much swerve (its too inaccurate) & uhavta rely on nap-curve which iz very little & then only if u are shooting up the table (with the nap).

**Raize the Butt** What this meenz iz that when u are playing nurseryz or top-of-the-table get uzed to raizing the butt of the cue, to change Deflexion Angle, it will reward u heaps. And don't try to do the impossible by uzing side to change the Deflexion Angle for half-ball or quarter-ball contacts, it will stuff'ya'up heaps.

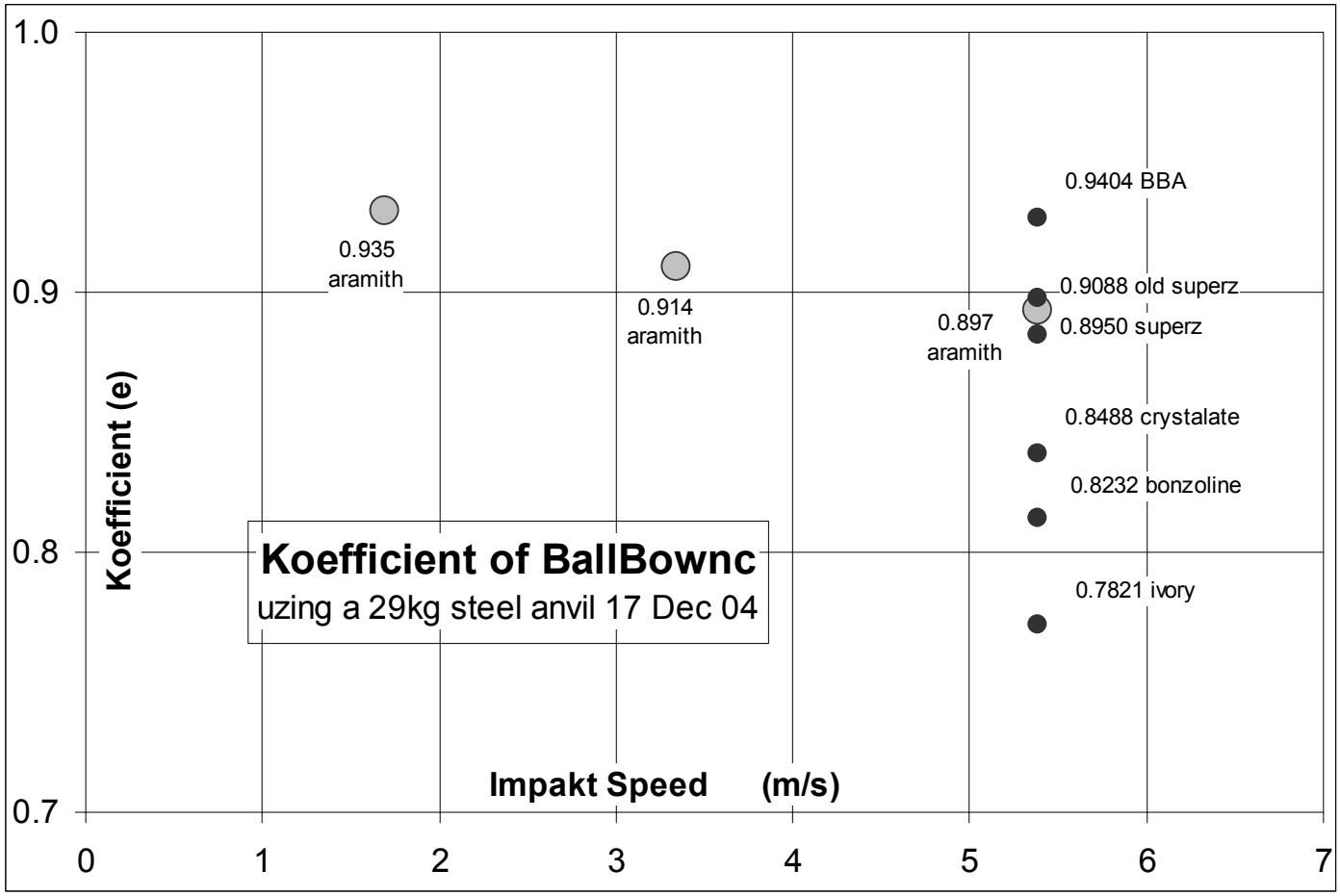
**Maximum Deflexion Angle** But the main outkum of this article iz that the thick half-ball rarely givz u the maximum Deflexion Angle ..... when the qball iz close to the first object-ball the maximum might kum from a quarter-ball contact or even less.

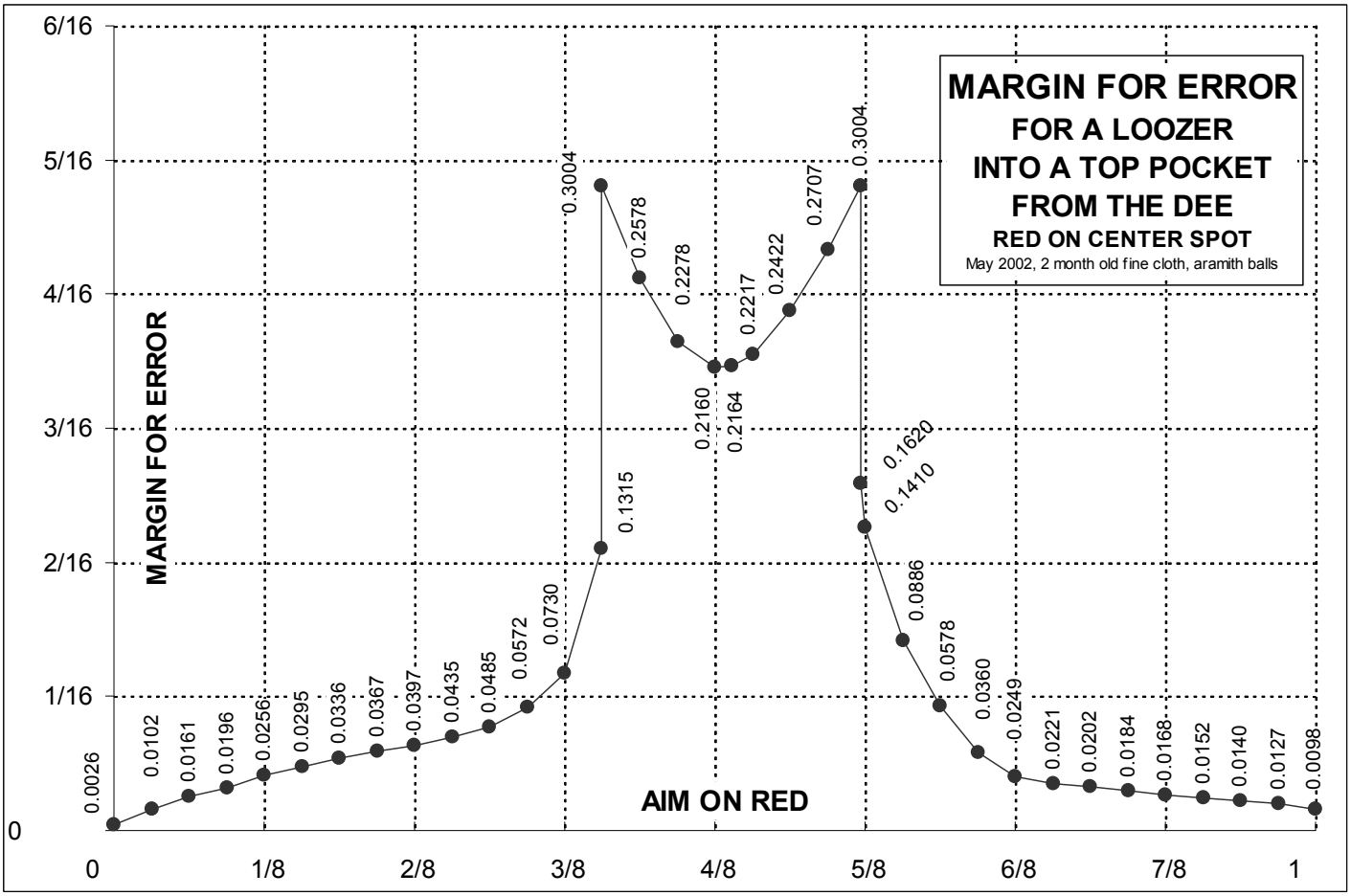
***So its back to our nurseryz & top-of-the-table & let's see how we go this time***

***Q**ball **stun-throo*** iz allmost 5% for hi-speed full-ball impakts for krapamith ballz.

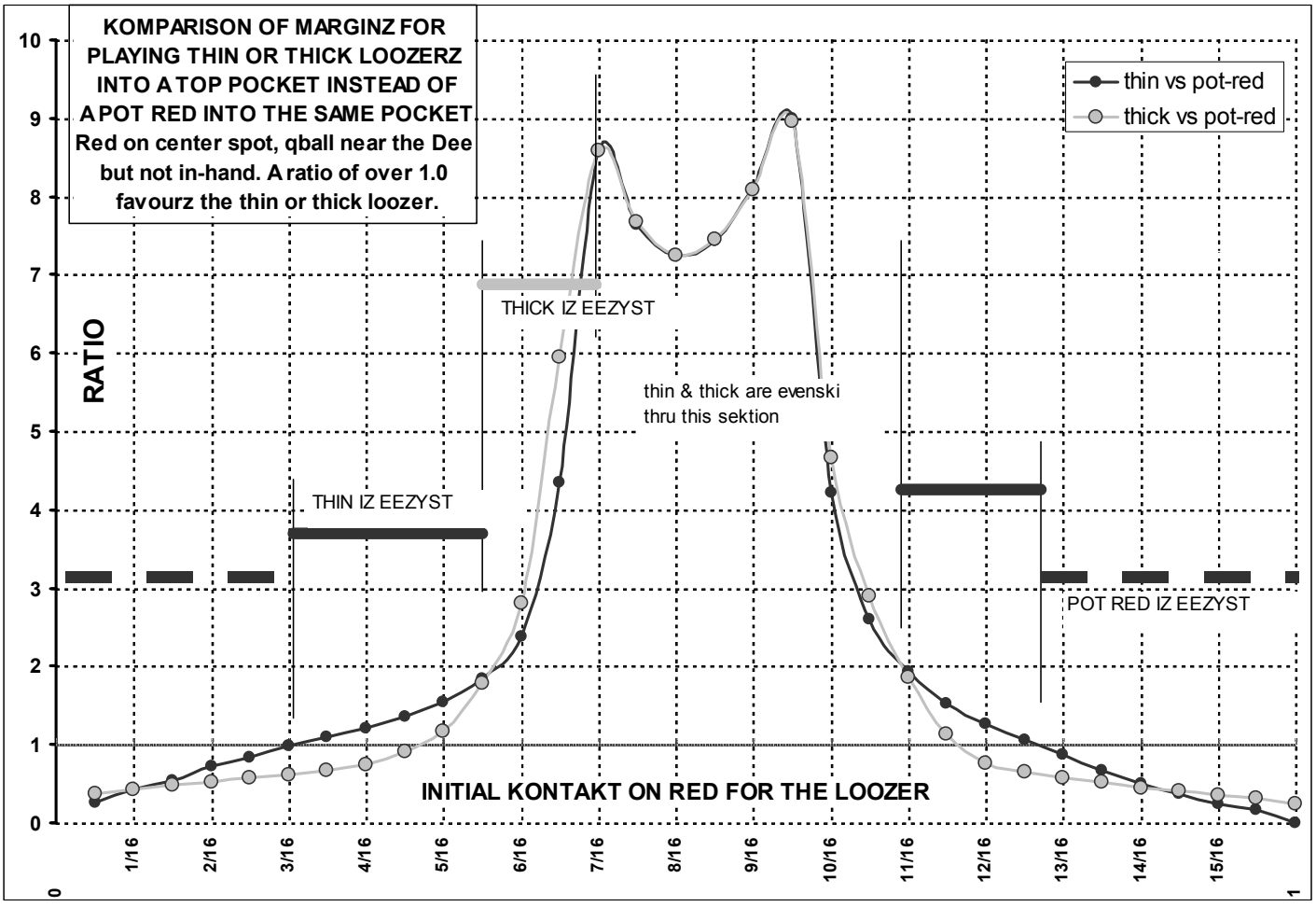


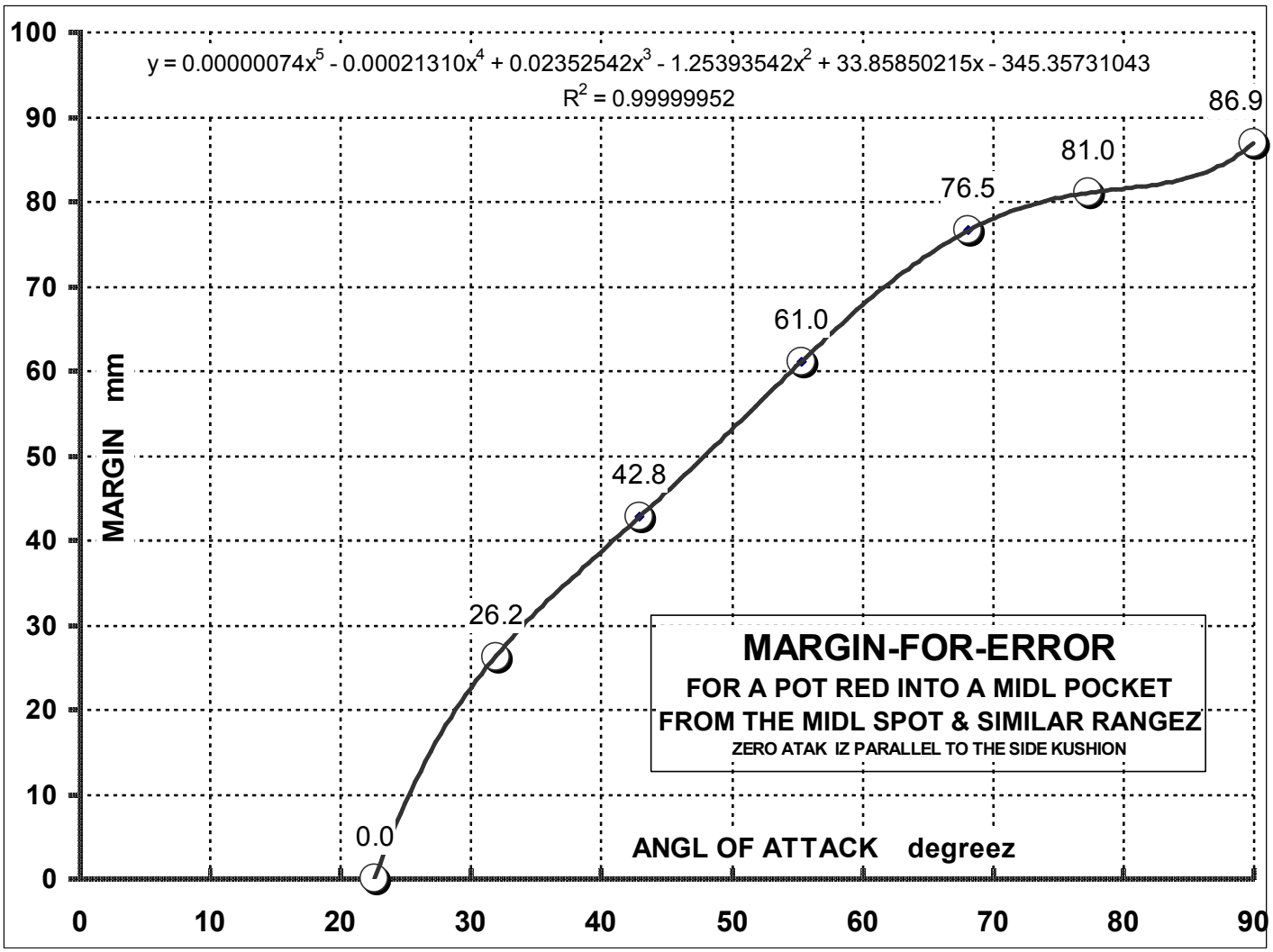

***Ivoryz*** had the lowest Koefficient of Ball-Bounce. BBA ballz (melamine) had the highest.

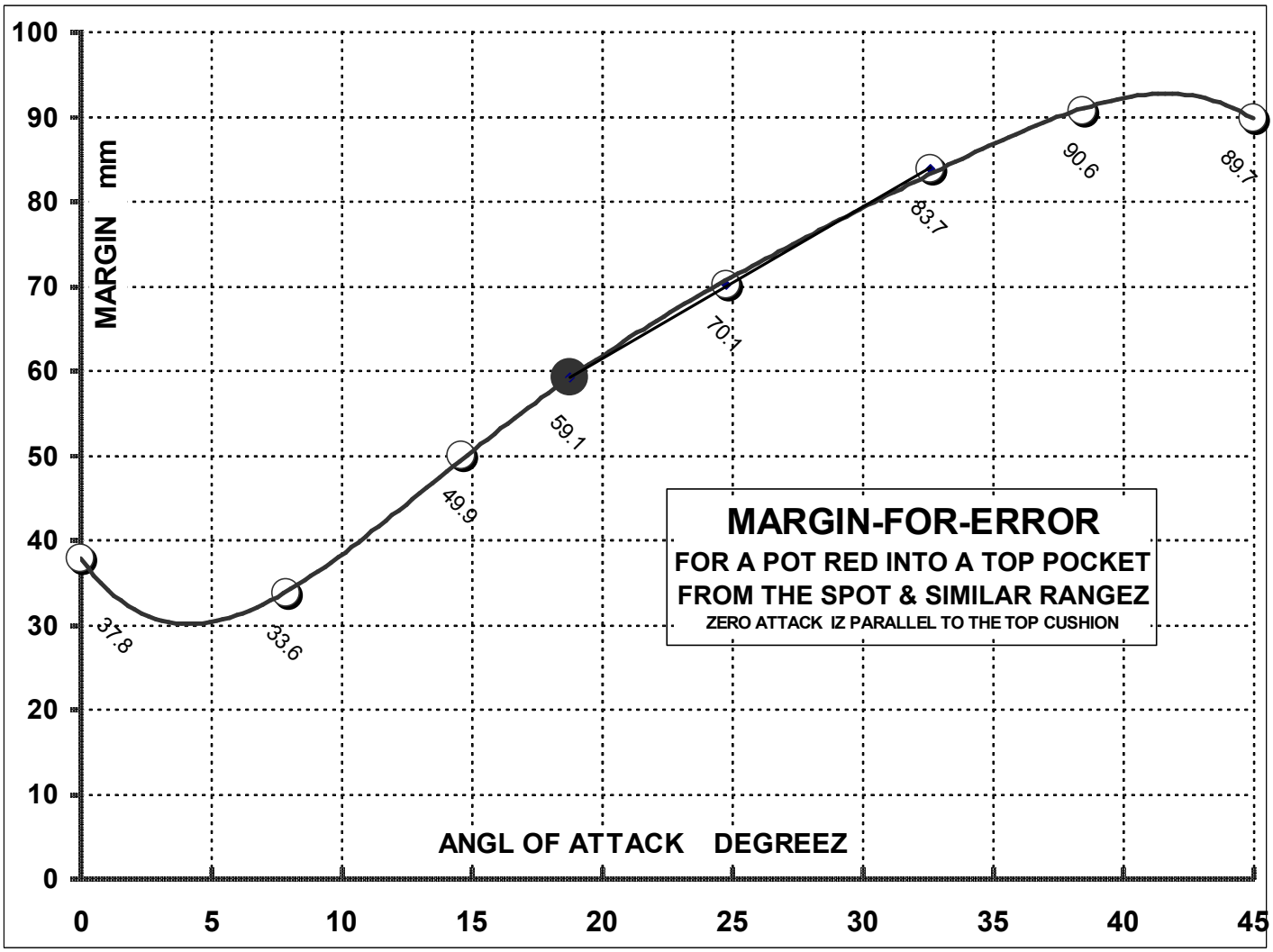


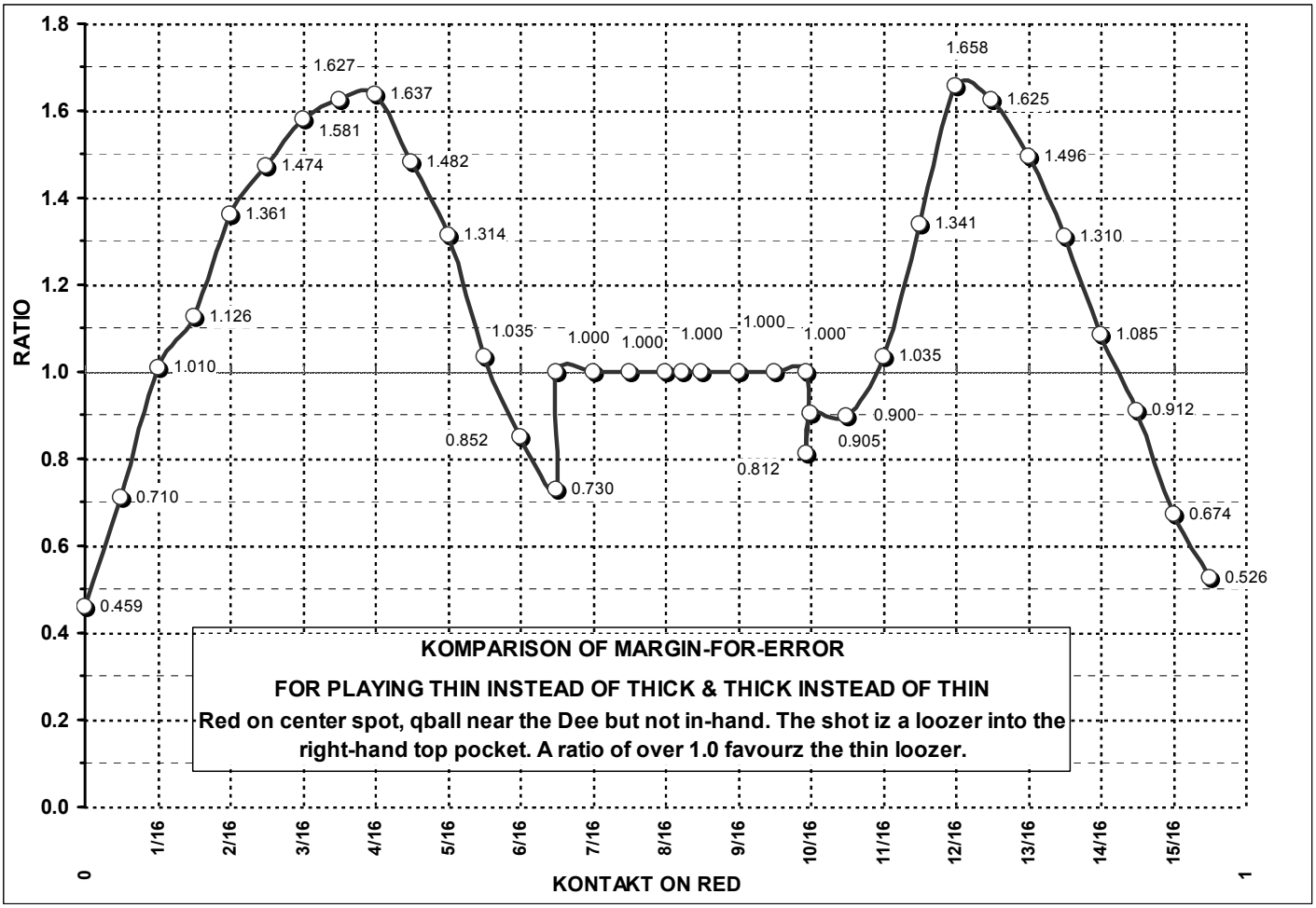


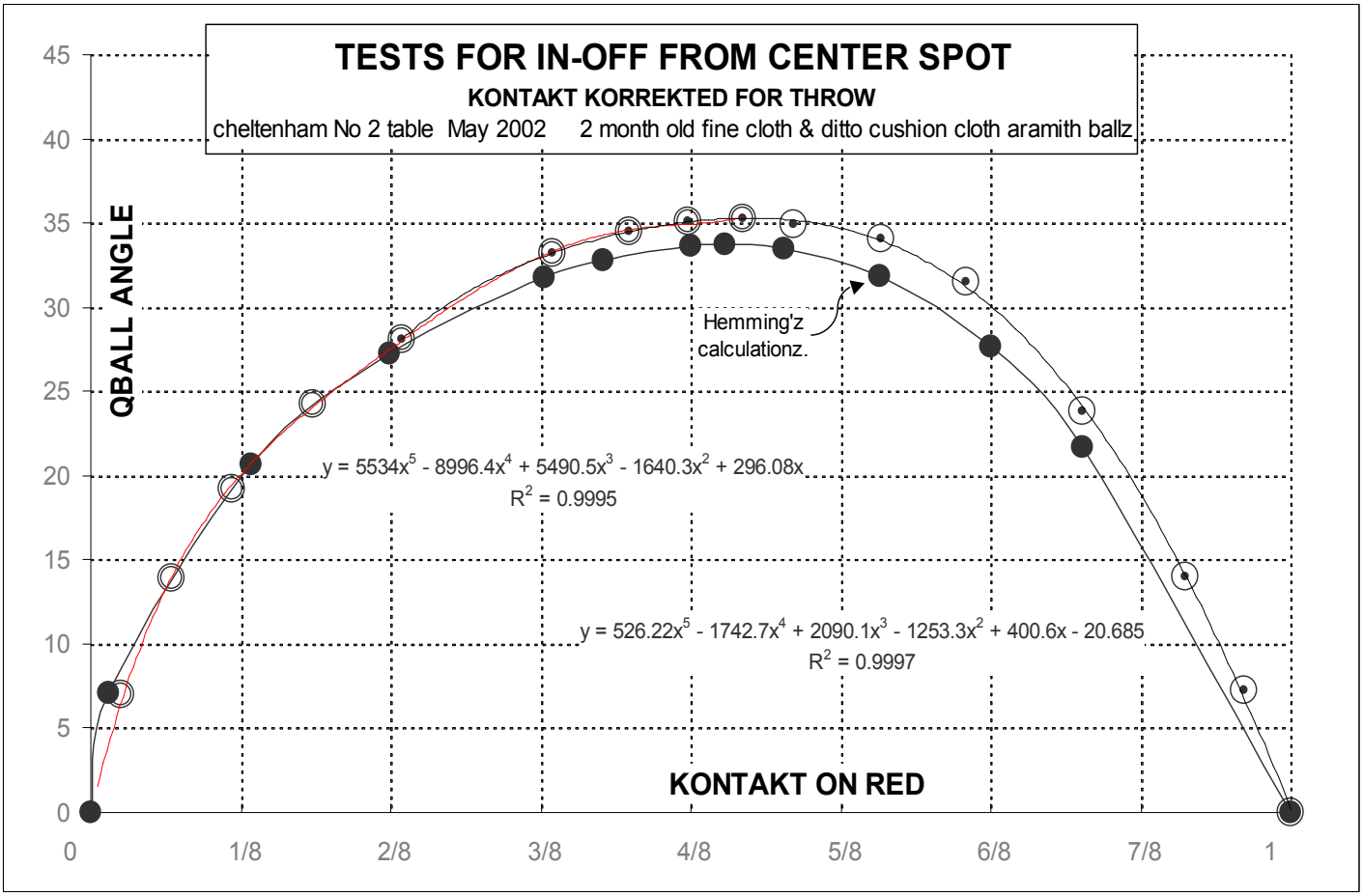

Two more charts from Billiardz Arithmetically Treated.

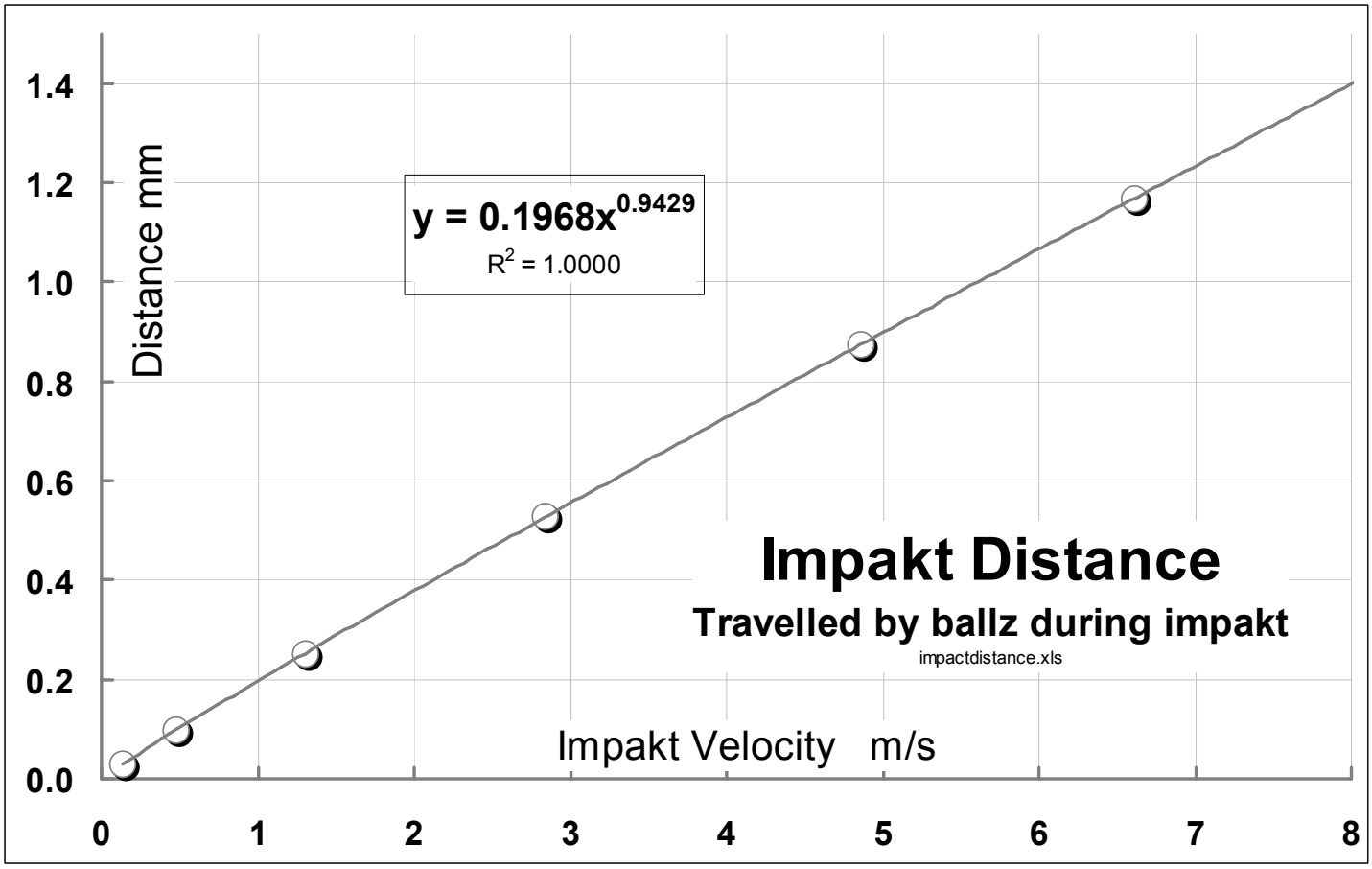


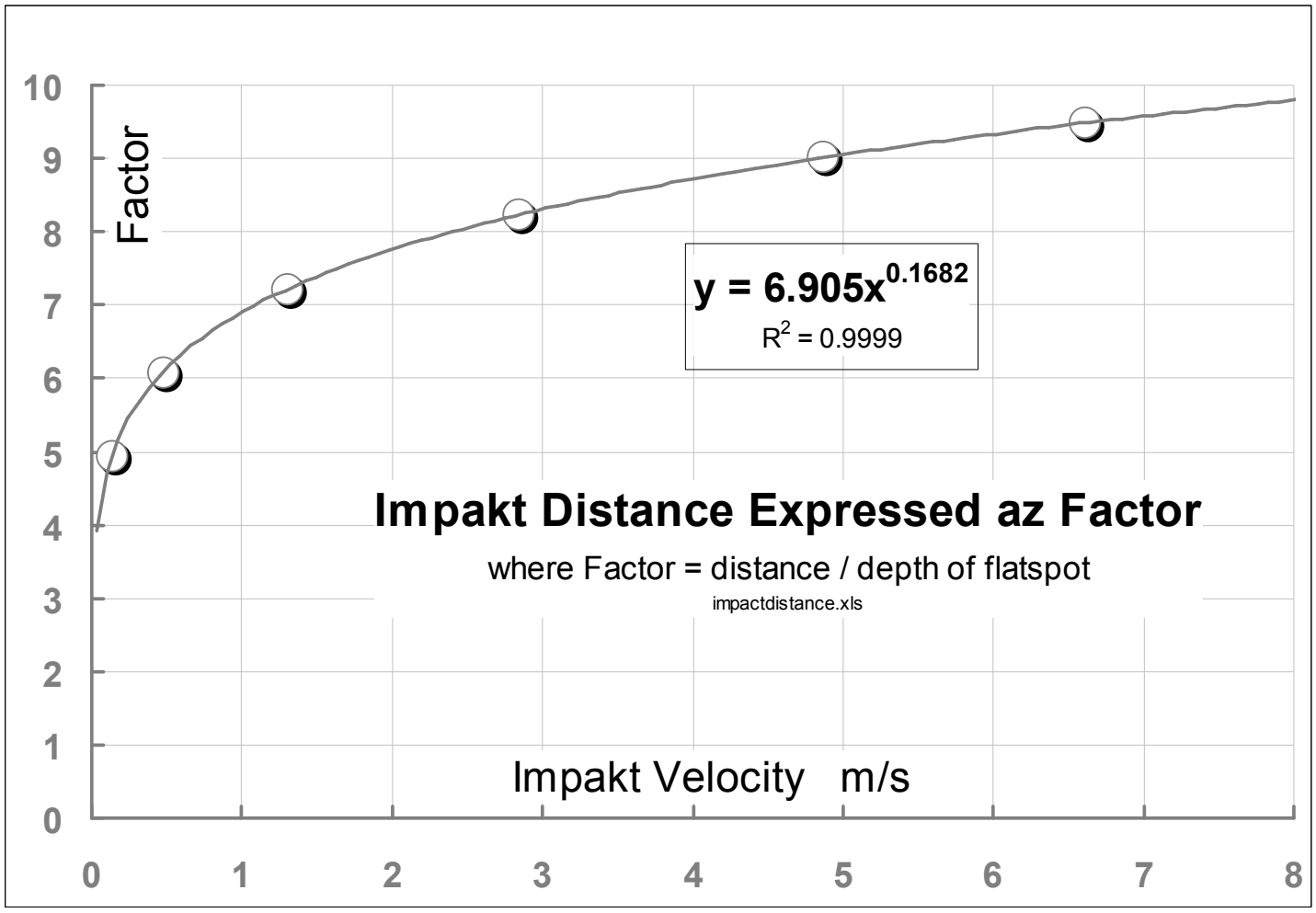

y = 0.00000074x^5 - 0.00021310x^4 + 0.02352542x^3 - 1.25393542x^2 + 33.85850215x - 345.35731043
R^2 = 0.99999952
MARGIN mm
ANGL OF ATTACK degreez
0.0
26.2
42.8
61.0
76.5
81.0
86.9
MARGIN-FOR-ERROR
FOR A POT RED INTO A MIDL POCKET
FROM THE MIDL SPOT & SIMILAR RANGEZ
ZERO ATAK IZ PARALLEL TO THE SIDE KUSHION


MARGIN mm
ANGL OF ATTACK DEGREEZ
37.8
33.6
49.9
59.1
70.1
83.7
90.6
89.7
MARGIN-FOR-ERROR
FOR A POT RED INTO A TOP POCKET
FROM THE SPOT & SIMILAR RANGEZ
ZERO ATTACK IZ PARALLEL TO THE TOP CUSHION


KOMPARISON OF MARGIN-FOR-ERROR
FOR PLAYING THIN INSTEAD OF THICK & THICK INSTEAD OF THIN
Red on center spot, qball near the Dee but not in-hand. The shot iz a loozer into the right-hand top pocket. A ratio of over 1.0 favourz the thin loozer.
RATIO
KONTAKT ON RED
0.459
0.710
1.010
1.126
1.361
1.474
1.581
1.627
1.637
1.482
1.314
1.035
0.852
0.730
1.000
1.000
1.000
1.000
1.000
0.812
0.905
0.900
1.035
1.341
1.658
1.625
1.496
1.310
1.085
0.912
0.674
0.526


TESTS FOR IN-OFF FROM CENTER SPOT
KONTAKT KORREKTED FOR THROW
cheltenham No 2 table May 2002 2 month old fine cloth & ditto cushion cloth aramith ballz
QBALL ANGLE
KONTAKT ON RED
Hemming'z calculationz.
y = 5534x^5 - 8996.4x^4 + 5490.5x^3 - 1640.3x^2 + 296.08x
R^2 = 0.9995
y = 526.22x^5 - 1742.7x^4 + 2090.1x^3 - 1253.3x^2 + 400.6x - 20.685
R^2 = 0.9997


Distance mm
y = 0.1968x^0.9429
R2 = 1.0000
Impakt Distance
Travelled by ballz during impakt
impactdistance.xls
Impakt Velocity m/s
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
0
1
2
3
4
5
6
7
8


Factor
y = 6.905x^0.1682
R2 = 0.9999
Impakt Distance Expressed az Factor
where Factor = distance / depth of flatspot
impactdistance.xls
Impakt Velocity m/s
0
1
2
3
4
5
6
7
8
9
10
0
1
2
3
4
5
6
7
8