

INOFFS CENTRE SPOT

The **HALFBALL** (or thick halfball) inoff angle is the foundation of English billiards. It is the maximum deviation angle taken by the qball (after it hits the red). Little has been written re inoffs, & mostly theoretical, so i did my own **TESTS**.

G W HEMMING BILLIARDS MATHEMATICALLY TREATED 1899

Hemming has a chapter on the inoff angle in his book. He derives equations for the angles taken for various contacts, & infers that.... *If the balls were perfectly elastic, 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's journey). This would occur slightly fuller than half-ball, ie at an angle of 28 degrees 7 minutes 30 seconds (ie 1 degree 52 minutes and 30 seconds fuller than half-ball which is 30 degrees, ie it is 0.5286 of full-ball).* My tests will check these numbers etc. Hemming has a lot of good stuff, but i have trouble following much of his article.

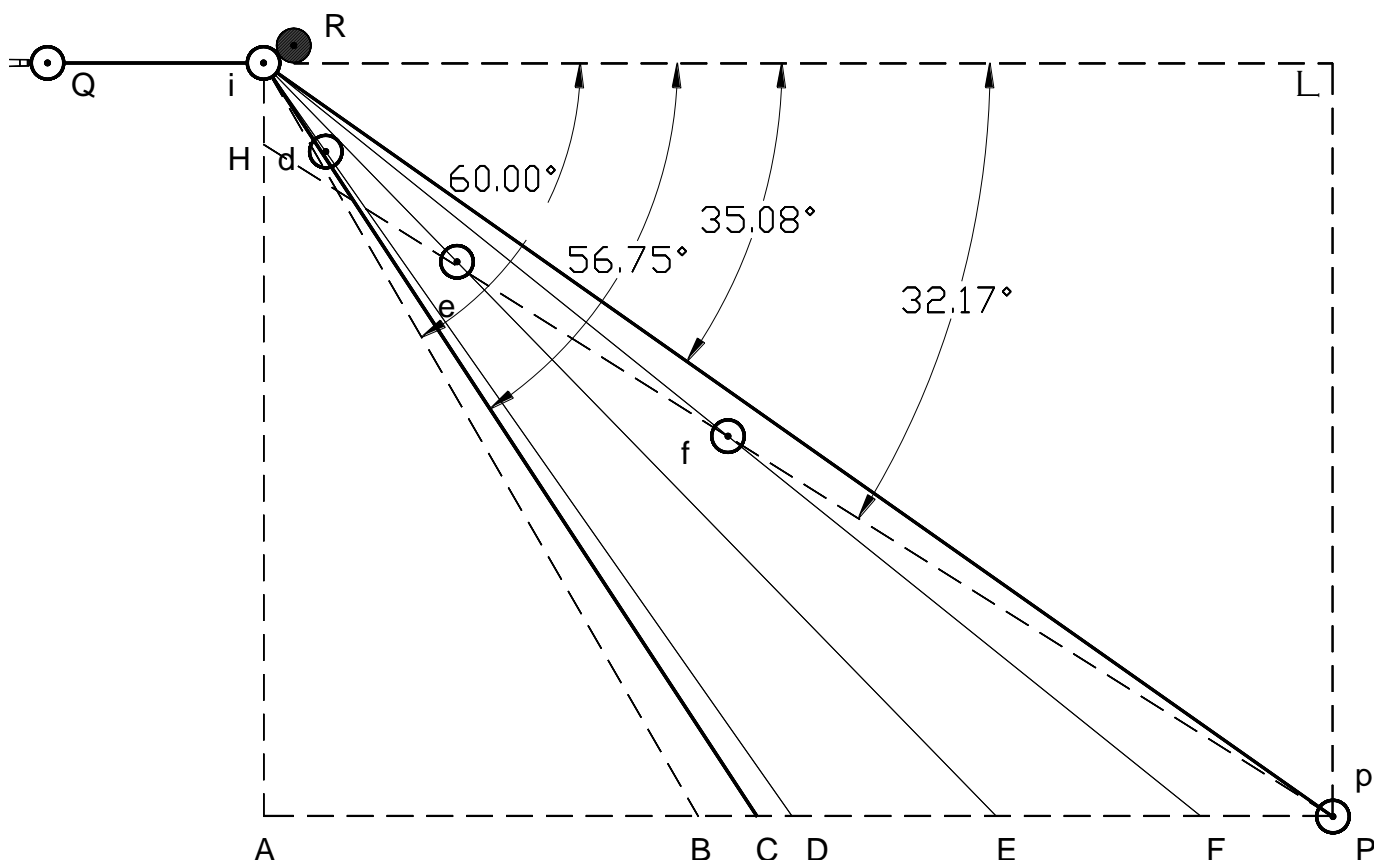
- His analysis is i think theoretical (but he mentions investigations, trials, experimental strokes etc).
- He says that for practical results one needs to estimate e , & he says that...*For good ivory e may be taken to be about $1/15$, according to results obtained from investigations independent of the billiard table.* [But then he doesn't use e in his calcs].
- He says.... *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 δ (meaning deviation angle) and subsequent investigations will show that this may exceed a degree and a half.* [ok i guess].
- He says.... *f , the friction between balls, is no more than $1/100$, and may be neglected.* [Frayed knot, it's about $1/20$ for bakelitish modern balls].
- He says that his deviation angle is independent of velocity. [Frayed knot, velocity affects stun-throo, & thusly angle].
- He says that by playing similar strokes on a fine cloth & on a much coarser cloth we can get large variations in the observed values of deviation angle. [Frayed knot, not by his definition of deviation angle, coz changing friction or roll resistance etc wouldn't change his deviation angle][It would affect my deviation angle, but not his][Hemming's deviation angle is simply the difference in angle of the qball before impact compared to its final angle after the qball is going straight (ie after serious parabolic skidding has ended)][Mac's deviation angle is different (see later)]
- He says..... *it is further observed that by increasing the coarseness of the cloth the maximum value of δ (deviation angle) may be increased by two or three degrees, as a few trials without any minute measurements seemed to me to show.* [Frayed knot].

INOFF TESTS FROM THE DEE - RED ON THE CENTRE SPOT

In fact i didn't play in-offs, i hit the qball onto the top cushion near the right top pocket. The **RED** hit the left side cushion. The qball trajectory & the red trajectory were measured by using lengths of timber laid along the cushions. Each timber had **BLUETACK** stuck along the face, with toilet paper laid loosely over the bluetack. A ball hitting the timber would leave the paper stuck to the bluetack, thus leaving a record. The qball was hit using a cue in the usual manner, using no side (plain-ball), & hi pace (enough pace to bring the red around to the centre line of the table off three cushions (were it not for the bluetack etc)(say 3 m/s). The results are shown in the following **TABLE & GRAFF**. The graff inkloads a plot of Hemming's theoretical deviation angles for comparison. Hemming's theoretical deviation angles are different animals to my deviation angles, & so they can't be compared simply. Hemming's deviation angle is the difference in angle of the qball trajekt before impact compared to its final trajekt angle after the qball is going straight (ie after serious

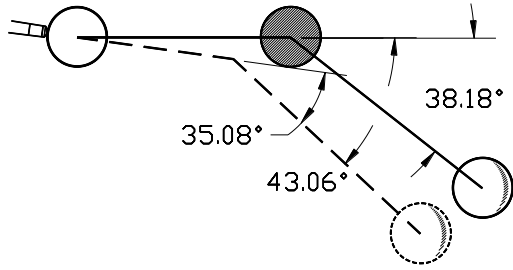
parabolic skidding haz ended). Mac's deviation angle iz different. I measured the XY position of the centre of the qball (Q) in the Dee before the shot, (i) at impact with the red, & (P) at impakt with the bluetack at the top cushion. Mac's deviation angle is the angle between the line Qi & the line iP. So, my deviation angle includes the initial kurv. So, for this & other reasons, my angles are wider than Hemming's.

INOFF 1 iz a not to scale drawing of my inoffs.



The maximum deviation angle iz gotten just az the qball parts company with the red. The line of travel at the end of impakt iz iC, this iz **56.75°**, which iz **3.25°** less than the **60°** assumed by **SKOOLKIDS** & shown here by the line iB. **60°** iz they say the theoretical initial angle if the collision iz perfektly elastic, which it never iz. And, it can never be perfektly **ELASTIC** koz after the collision both balls will be **RINGING** like a bell, & ringing robs **ENERGY**. And, the sound of the impakt robs energy, & i reckon that the energy of the sound of the **KLICK** iz a (slightly) different animal to the energy of the ringing, ie it iz an additional loss (not important today i guess). But then we might start to worry about energy versus **MOMENTUM**, which kan drive budding theorists to an early grave. Anyhow where were we. Hence our halfball long-loozer enjoys an infinite number of deviation angles between **56.75°** & **35.078°**, depending on the distance from red to pocket (ie RP). Hmmm, no i am wrong, i forgot that the maximum distance possible for RP on a 12 ft table iz almost double the RP distance for when the red iz sitting on the **MIDSPOT**, ie **35.078°** iz not the minimum possible angle. But i am not going to go to any trouble to estimate or measure the actual minimum angle. When a red-ball player gets down on a long-cannon, she sees the 3 balls. Her eyes are more familiar with the needed angle or contact etc for her favorit separation between the qball & red, & for her favorit range between the red & the yellow. Theze will probably be for her old familiar long-loozer off the midSpot with qball in-hand, this shot being near'nuff the one taking up more of her praktis hours 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 shiny Krappamyths to the nice big old

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



INOFF 2 The eyes hav their own natural verzion of the deviation angle. Her eyes see 3 balls (or 2 balls & a pocket), hence angles are seen to be defined by the centres of the balls. More than that, angles are naturally based on the 3 balls sitting in familiar pozzys. Hence in **INOFF 1** she sees & recognizes & remembers the angle QRP, which happens to be about **38°**. **INOFF 2** shows what i meen.

With the 3 balls in this (or any) pozy, her eyes naturally draw a line from the centre of the qb to the centre of the red to the centre of the yellow (which in InOff 2 iz drawn to form her favorit midSpot long-loozer angle, ie 38°).

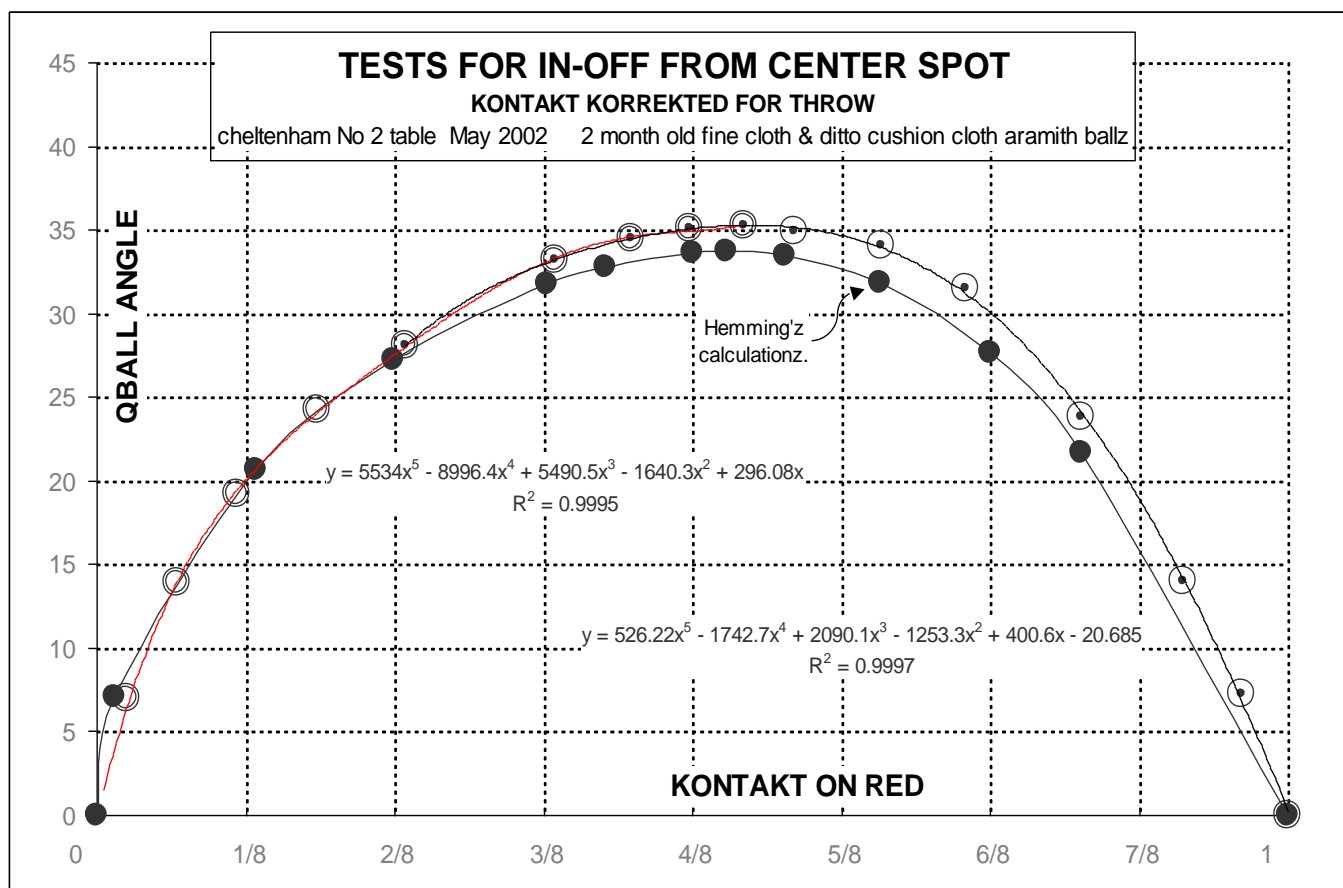
But in InOff 2, when she hits the red half-ball, the qb's **35°** deviation angle will take it wide of the yellow, az shown by the broken yellow (i assume here that we are talking about a soft shot, with allmost zero kurv after impakt, & i assume that the **35°** holds good at all speeds). The **38°** angle in InOff 2 iz az i allready sed the long-loozer angle QRP in InOff 1. U see lots of such misjudgments all over the table in matchplay, especially az the qb gets closer to the red.

TABLE 3 MY INOFF DEVIATION ANGLES

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 (degrees).

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			

GRAFF 4 MY INOFF DEVIATION ANGLES



The plot of Hemming's angles has a different shape to the plot of my results, mainly because Hemming did not allow for **THROW** (ie due to ball to ball friction). The calculated kontakt on red is **FALSE** unless throw angle is added to the measured angle. The throw & throw angle would be zero if the qball had natural **ENGLISH**. Throw also narrows the qball's deviation angle. As can be seen in the graph there seems to be an **ANOMALY** at about 2/8, the plot has a slight **CONCAVITY**. The explanation is that throw is very significant at about 1/4 ball (thusly the concavity). In my tests, the maximum qball deviation angle was **35.278°** degrees, & this occurred slightly fuller than half-ball, ie at an angle of **26.84°** (ie **3.16°** fuller than half-ball, ie **0.5485** of full-ball). **TABLE 5** Some of the results are as follows.

Initial Contact	Initial Contact	Initial Contact Angle	Qball Deviation Angle	
Full-Ball	1.0000	90.000	0.000	
Three-Quarter	0.7500	48.590	30.018	
	0.5469	33.153	35.278	Maximum
Half-Ball	0.5000	30.000	35.078	
Quarter-Ball	0.2500	14.478	27.552	
Zero-Ball	0.0000	0.0000	0.000	

The difference in the angle of the red's trajectory to the cushion, compared to the angle of the qball's trajectory before hitting the red, gave me what could be called the **APPARENT CONTACT ANGLE**. But I needed the **ACTUAL** contact angle. The main difficulty with my method was that there was no easy way of measuring the contact angle of the qball on the red ball. The measured or apparent contact angle would be near'nuff correct if there were no **FRICTION**. But I had to apply a negative

CORRECTION to allow for the throw resulting from ball-to-ball friction. The correction is zero degrees for a full-ball contact, & rises linearly to minus **2.8624°** (ie minus 0.05) for the thinnest contacts. This means that the contact is up to **2.8624°** thinner than what the bluetack says. I had to make one more correction to the above contact angle. The **INITIAL** contact (the contact aimed for) is not the **FINAL** contact. The contact changes during impact, due to the temporary **FLATSPOT**, & there is a considerable difference between the initial contact & the final contact. The actual (average) contact is up to **0.7°** thinner than the initial contact, the harder the impact & the finer the contact the larger the necessary correction. I reckon my tests were at say 3 m/s, & so the second correction varied from zero degrees for full-ball contact rising to plus **0.6°** for the thinnest contacts. So, the "initial contact" & "initial contact angle" in the above results each show the theoretical true initial contact. They are based on the **MEASURED** bluetack angle "minus" the **CORRECTION** for friction & "plus" the **CORRECTION** for flatspot.

SIDE & VELOCITY

As already mentioned the above deviation angles apply for a qball with pure **ROLLING** (no stun or side). **CHECK**-side narrows the deviation angle a bit, & **RUNNING** side increases the angle a little. One day if & when i have time i will repeat the above tests using check-side & running-side. Qball velocity also affects the angle. As mentioned the above tests were carried out at say 3 m/s. Lower speeds usually result in narrower angles, & higher speeds usually result in larger angles, koz of the larger kurved bit of the trajectory. Alltho **LOCOCK** sed that at times higher speeds give a lesser angle, I will hav to look into this one day to see what he meant. New cloths are usually very **SLIPPERY** for a couple of months, & this increases the angle, mainly due to the larger initial kurv. Similarly, **SLOW** tables also increase the angle, due mainly to the natural need to hit the ball harder, due mainly to the larger initial kurv. I have a theory that thick **NAPS** hav very low friction (in some directions), & so the initial kurv is large. On top of this, such cloths are usually very slow, & so the initial kurv is very large. If this cloth is also relatively new & slippery, the initial kurv is very-very large. This would explain the remarks often found in old books that heavy cloths can widen the deviation angle, it's all due to the initial kurv that's all.

GENERAL

Keep in mind that the in-off tests were done with **SUPER ARAMITH** balls. The corrections for the red's trajectory & the qball's trajectory, for friction, were based on friction tests on Super Aramith balls. But, the corrections for impact angle were based on impact tests & load tests done with **SUPER CRYSTALATE** balls. It's a bit of a **MONGREL** effort, but i reckon that Super Aramith & Super Crystalate are pretty similar in regard to softness, friction, elasticity etc, & so i reckon that the results are ok-ish. Not that any of these test results are of any use in actual play. All players learn to recognise deviation angles for various contacts by lots of never-ending practice. They play by feel. Some players concentrate on getting to recognise the quarter-ball, half-ball & three-quarter-ball contacts & deviation angles, & they try to stick to these. And when faced with some other angle, they use their favourite contacts & angles as a reference to help judge the stranger. But praps these results will help to settle some old & new arguments.

