

The factors to be taken into consideration are:

1. The separation distance of balls.
2. The angle of departure of the striker's ball after hitting the target ball and the distance the striker's ball travels relative to the distance traveled by the hit ball.
3. The way the stroke is played (ordinary drive with vertical handle or with the handle angled forward).

**Stroke straight ahead:** At a separation distance of 2 mm from the ball to be hit, if the striker plays a normal firm stroke straight ahead it will generally not be a double tap because the mallet clings to the striker ball for an average of 2 mm or more, the distance shown in the chart below, and no DT can occur.

However it will still be a fault as it violates both AC Law 28 (a) 8 and WCF GC Rule 13(a)8. There is no colloquial term for this type of fault, but it has been suggested by Bill Arliss that it ought to be known as a “ball crush” ouch!

**Glancing Strokes-gross:** If the striker's ball departs the hitting position, in the large an angle of approximately between 88 and nil deg.( as illustrated below) , it will very probably be a fault.

We know from Prof. Stan Halls work (chart below) that in a **soft** stroke the ball stays in contact with the mallet for 1.19 mm, and in a **hard** stroke the ball stays in contact with the mallet for 3.7 mm.

Assuming a gap of 2 mm, if a soft straight on shot is played (1.19 mm gap) a double tap **could** occur.

But if the same stroke is played firmly where the ball and mallet travel distance exceeds the 2 mm gap a double tap **will not** occur, but a fault results under Rule 13(a)8 ( sometimes called a ‘ball crush’, sometimes incorrectly also colloquially called a ‘push’ or “to maintain contact”). What ever it is called, it is a fault.

In other words; in order for it **not** to be:

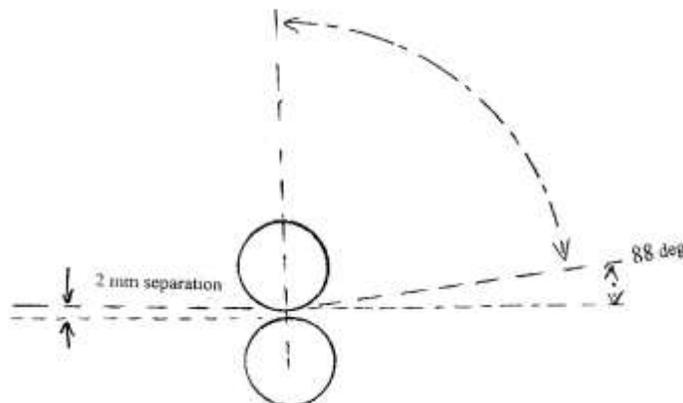
- a “**double tap**” on a dead ball under AC Law 28(a)7 [ 2000 Laws ] or 28(a)7 B&C [ 2008 Laws] or

- a “**ball crush**” fault, under AC Law 28(a)8 and WCF GC Rule 12(a)8:

-it needs to exit after the hitting (contacting) position almost at right angles. (approximately 88 to 90 degrees).

-it also means the striker's ball ought to travel much further than the hit ball, as it will just skim the hit ball.

If the distance between the balls is 2 mm and a “straight on” stroke or a stroke played that deviates after hitting the target ball is, from Nil to 88 degrees, will most probably be a fault ( a DT or ‘ball crush’)



**Glancing Strokes – Fine:** Example: If the striker ball departure angle is approximately 88 to 90 degrees it will **not** be a fault because the tangential distance will be approximately ten times the direct 2mm separation distance, eg. at 2 mm  $\times 10 = 20$  mm, therefore greater than the “maximum travel distance during mallet and ball contact”, which is 3.7 mm.

This condensed chart is derived from the Oxford Croquet site by Prof. Stan Hall, member of Chatswood Club, NSW, Jan 1994.

<http://www.oxfordcroquet.com/tech/hall/index.asp>

### Contact times – Single ball strokes – Dawson Mark II balls – Normal Stroke

The distance the ball traveled. metres	Contact time between the balls. milliseconds (averages)	Initial velocity of mallet. metres/second	Travel distance during ball & mallet contact. millimetres
24 (hard shot)	0.89	7.3	3.7
12	0.94	5.2	3.0
2.7	1.03	2.2	1.6
0.6 (soft shot)	1.32	1.15	1.19

(1 millisecond is one thousandth of a second)

### Summary and quotations:

#### Quote: Prof Stan Hall:

“If the shaft of the mallet was greatly inclined to the vertical (as in a hammer stroke) the contact time was substantially more because the ground prevented the ball from springing away from the mallet.”

#### Quote: Dr. I Vincent, Chairman ILC (International Laws Committee)

“although the balls may be separated by 2mm along the line of centers in your example, the distance between the balls along their common tangent (which is the distance the striker's ball must travel before hitting the other ball in the limiting case of a glancing blow) is about 10 times greater, and hence much more than contact distance between the mallet and striker's ball. A fault under those sub-laws is therefore unlikely for a glancing contact.”

#### Quote: Dr. I Vincent, Chairman ILC (International Laws Committee)

“I don't see that it is possible to lay down such a hard and fast rule, nor to observe the stroke with such precision: the acceptable angle of swing will depend on the precise separation of the balls and strength of shot and referees don't carry a protractor. If the cleared ball is just snicked, the direction of its short travel will be heavily influenced by pull and irregularities in the court, so an angle of less than 88 degrees between the directions of travel of the two balls is not necessarily the result of a fault.

“The advice I would give to referees is to compare the directions and relative distances that balls have moved with what they would have expected for a similar stroke with the balls far enough apart that no fault was committed (but not so far that the SB has started rolling before the impact). If the result of the actual stroke is outside the range expected for a clean one then a fault should be declared.

“In simple cases, such as a flat impact along the line of centres, a rule of thumb, such as an 8:1 ratio, can be used to derived from that, but I'm not convinced that things are as straightforward for glancing impacts.”

**Quote: Gordon Smith, Chairman of the WCF Golf Croquet Rules Committee**

“Some specific comments on 2 mm separation:

“When two balls are separated along the line of centres by 2mm, and a stroke is played at 45 degrees to the LoC, the striker's ball travels nearly 4mm before hitting the target ball, so the mallet and striker's ball should be separated. Now (pure speculation with nothing other than intuition to justify it) if the lawn condition is dry and fast, I would expect there to be so little holding up of the striker's ball that there would be no DT. However if the lawn was soft and slow there could be sufficient holding to cause a DT. But in either case there would be a fair chance that a stroke played with abrupt stop would be clean, even if played at 45 degrees.

“As the angle increases from 45 degrees towards 90 the likelihood of a clean stop shot also increases. Further as the distance between the balls increases so the likelihood of an fault decreases.

“As the balls separate after such a stroke the angle between the lines of departure approaches 90 degrees. I don't believe we can be more precise than that. 88 degrees is a pipedream figure. I doubt if there is any theoretical justification for 88 degrees (my dynamics is far too rusty to try to figure it out even if I knew coefficients of restitution or friction or what have you.) Rather such angles are (in my mind) based on empirical evidence, where lawn slopes and other influences affect the ball travel. I suspect that 80 and perhaps even 70 degree separation may be clean, especially as the original ball separation increases to 4,5 or more mm.

“A rough guideline:

“Balls separated by  $<2\text{mm}$  = it is likely that only a glancing blow will be clean

“Balls separated by  $>2\text{mm}$  = clean stop strokes can be played in which the balls separate at close to right angles and the striker's ball travels further.

“As the original separation increases so the angle of separation of a clean stroke may drop and the balls travel nearer to the same distance.

“Comments on push:

“You use the word push to refer to what happens when Rule 13(a)8 is contravened. This is totally inappropriate. What we are dealing with in this rule is a stroke that would be clean, except that before the ball and mallet have separated the striker's ball hits another ball. If this is to be called a push then ALL strokes are pushes. If in stroke the striker's ball touches a hoop while still in contact with the mallet we call that a crush (not a push), so if you must call it something go with Bill and call it a ‘ball crush’. I would prefer that it be called a stroke which contravenes Rule 13(a)8.

“A snick on a ball close to the striker's ball is not a fault under GC Rule 13(a)8.”

**Quote: Bill Arliss, Chairman of the CA Golf Croquet Laws Committee**

“A double tap occurs in the straight on hit situation as the strikers ball stops dead when it hits the second ball and allows the mallet to catch up with the strikers ball. In a glancing situation there is very little deceleration of the striker's ball and the likelihood of a DT recedes very quickly. As our high speed film

tests show, the ball leaves the mallet at a greater speed than the mallet head speed and thus there is a very finite deceleration needed if the mallet is to catch up with the striker's ball. Don't forget that the mallet itself will decelerate due to transfer of energy to the striker's ball.

“I am very unhappy when anybody describes the situation under GC Rule 13(a)8 as ‘maintained contact’ or even a ‘push’. The actual contact time in these situations is very small compared to the contact time in say a pass roll in Association Croquet. I am very aware that we legalise croquet shots in AC by referring to ‘observable’ times of contact i.e. times that the human eye can recognise. I use the term ‘ball crush’”.

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**Interim Ruling:** Please use the term “ball crush” for a fault under WCF GC Rule 12(a)8.

This term ought **not** to apply to AC Law 28(a)8 and a fault on a dead ball under Law 28(a)7 [2000 Laws] and Law 28(a)7 B&C [2008 Laws] until ratified by the ILC.

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**Additional Reading:**

**When a Mallet Strikes a Ball** by Prof. Stan Hall in *ACA Gazette* 1999 or 2000 which is a quick summary of the *ACA Golf Croquet Referees Manual* 2008 — final version, Section GC B9, Page 6.

<http://www.oxfordcroquet.com/tech/hall/index.asp>

The *ACA Association Croquet Referees Manual* (both 2003 and revised 2008 versions), Section B9.

**Double Tap After a Banana (or Worm) Cannon** in the *ACA Association Croquet Referees Manual* 2008, Section B9, page 4.