Roulette Questions

Version 0.3 Beta

25 November 2007

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Brief summary of rules

A roulette wheel contains equally sized numbered slots. The wheel is spun and a ball is spun within the wheel in the opposite direction. Eventually the ball settles in one of the slots. Gamblers bet on the number of the slot. Payout odds differ for the different available bets.

Regional Variations

Roulette is a legal method of throwing your money away in Casinos in the Australian Capital Territory and in the states of New South Wales, South Australia, Queensland, Tasmania and Victoria.

37 vs 38 slots

Internationally, roulette wheels come in two forms.

- The 37 slot wheel, the slots being numbered 0 to 36.
- The 38 slot wheel, the extra slot being labelled “00”, pronounced “double zero”.

In Australia, it seems the 37 slot wheel is always used, though sometimes the legislation gives the casino a choice.

- In Queensland, South Australia and Tasmania the 37 slot wheel is mandated.
- In ACT, NSW and Victoria the legislation allows both the 37 and 38 slot wheels, but according to the web sites of the relevant casinos, only the 37 slot wheel is used.

Names

In Australia, the name “Roulette” is used in most locations.

- In NSW, Queensland, South Australia and Victoria, the game is consistently called Roulette.
- In ACT, the relevant legislation calls the game “American Roulette”, but the web site of the relevant casino simply calls it “Roulette”.
- In Tasmania the relevant legislation uses the name “Roulette”, but the web sites of both casinos use both this name and “American Roulette”.

Some international sources refer to the 37 and 38 slot versions as “European Roulette” and “American Roulette” respectively. However, these labels are apparently no longer accurate for Europe or America.

These labels are also inconsistent with Australian usage. With respect to the 3 locations where the legislation allows both the 37 and 38 slot wheels:

- In ACT and NSW, the name of the game isn't changed depending on the number of slots.
- In Victoria the 37 slot version is called "Roulette" and the 38 slot version is called "Double Zero Roulette".

In Victoria, the legislation also allows "French Roulette", which is identical to "Roulette" except that the language used is French rather than English. That is, all the bets are named in French. The relevant casino's web suggests it does not offer "French Roulette". (It is hard to imagine Australian gamblers standing for it!)

The Tasmanian legislation includes the statement that "Roulette tables will be of the American type with cloths marked in a manner similar to that shown in diagram A." Rather than referring to the number of slots on the wheel, this statement appears to be indicating that the words appearing on the table should be in English rather than French.

In NSW, the relevant legislation also allows the use of a "Chinese Horoscope wheel". This is still a 37 slot wheel, but the 36 non-zero numbers are divided into 12 sets of 3 adjacent numbers, a different symbol from the Chinese horoscope being attached to each of the 12 sets. The casino's web site does not indicate that the Chinese Horoscope version is offered.

Computerised Betting – Automated Transaction Stations

In traditional Roulette, bets are made by placing chips in the appropriate sections of the table layout. After the result of the spin is determined, the relevant casino employee collects the chips of the losing bets, and returns the chips of the winning bets (if any) along with the winnings.

More recently casinos have been allowed to use a computer system to record bets and pay any winnings. Each gambler has their own "Automated Transaction Station" (ATS) in which they deposit cash and on which they enter their bets. The casino employee enters the winning number into the computer, which calculates any winning payouts and credits the accounts of the appropriate gamblers. This reduces the risk of human error in calculating payouts. More importantly, it greatly increases the number of games which can be played in a fixed time, ensuring that the gamblers lose their money to the casino faster. It also reduces the Casino's wage bill, by allowing more gamblers to be involved in a single game. The traditional form only allows perhaps half a dozen gamblers per table, since the human supervisor must manually collect losing chips and pay winnings in chips. By contrast, a computerised betting system eliminates the need for handling chips. The Victorian rules allow up to 50 gamblers at a single game, while the NSW rules allow up to 24.

- In ACT, NSW and Tasmania and Victoria, the computerised betting version of Roulette is called Rapid Roulette.
- In Queensland the relevant legislative instrument does give a clear name for this system. The relevant casino's web site calls it "Roulette (Touchbet)".
- In South Australia it is called "Touchbet Roulette".
- Curiously, in Victoria the rules of Roulette allow the variation called "Touchbet Roulette", while there is also a completely separate set of rules for "Rapid Roulette". It isn't clear why these two forms exist. The web site of the relevant casino suggests that only the "Rapid Roulette" form is in use. There are minor discrepancies between the two forms and between these forms and the traditional form. One oddity is that while the legislation allows the traditional form to be played with either the 37 or 38 slot wheel, for both Touchbet Roulette and Rapid Roulette the 37 slot wheel is mandated.

In the following questions, unless specifically indicated otherwise, assume the 37 slot wheel is in use.

Question 1 – Single Number Bet

The simplest roulette bet is a single number bet. This bet wins if the ball comes to rest in the slot with the chosen number. It loses if the ball comes to rest in any other slot.

(a) Determine the probability that a particular single number bet wins.

(b) As in most casino "games of chance", the possible winnings in Roulette are specified by payout odds, so the possible winnings are proportional to the size of the bet, and so the expected loss is also proportional to the size of the bet. Hence we can simply determine the expected profit for some simple amount such as \$1, and scale the result as required. If the expected profit on a \$1 outlay was say $-\$.03$, then we can conclude that the expected loss is 3% of the outlay for any size of bet.

The payout odds for a winning single number bet are 35 to 1. That is, if you bet \$1 and win, you receive your \$1 stake plus another \$35. If you lose the bet, you forfeit the \$1 stake. Determine the expected profit for a \$1 bet. (The answer will be negative, since casino games of chance always favour the casino, not the gambler.)

(c) Verify that, if there had been only 36 slots on the wheel instead of 37, but the payout odds remained at 35 to 1, this would be a "fair bet", meaning the expected profit would be zero.

Question 2 – Red or Black

Recall that 18 of the numbers on the wheel are red, 18 are black, and the zero is green. If the gambler bets "Red", the bet wins if the ball comes to rest in a red slot. It loses if the ball comes to rest in a black or green slot. The bet "Black" wins if the ball comes to rest in a black slot. It loses if the ball comes to rest in a red or green slot.

(a) Determine the probability that a "Red" bet wins. Repeat for "Black".

(b) The payout odds for a Red or Black bet are 1 to 1. That is, if you bet \$1 and win, you receive your \$1 stake plus another \$1. If you lose the bet, you forfeit the \$1. Determine the expected profit for a \$1 bet.

(c) Verify that, if there had been only 36 slots on the wheel instead of 37, with the slot removed being the green zero slot, but payout odds remained at 1 to 1, this would be a "fair bet".

Question 3 – General formulae for standard bets

All the standard bets in Roulette take the form that the bet wins if the ball comes to rest in one of n particular slots, where n is one of the values: 1, 2, 3, 4, 6, 12 or 18. In Question 1, $n=1$. In Question 2, $n=18$. The full range of the standard bets is given below.

n	Bet Name	Payout odds
1	Straight up (ACT, NSW, Qld, SA, Vic) aka One number (NSW, Qld, SA) or Straight (Tas)	35 to 1
2	Split (ACT, NSW, Qld, SA, Tas, Vic) aka Two numbers (NSW, Qld, SA)	17 to 1
3	Street (ACT, NSW, Qld, SA, Vic) aka Three numbers (NSW, Qld, SA)	11 to 1
4	Corner (ACT, NSW, Qld, SA, Tas, Vic) aka Four numbers (NSW, Qld, SA) or Square (Tas) Four-line (Tas)*	8 to 1
6	Six numbers (NSW, Qld, SA) aka Six-line (ACT, NSW, Qld, SA, Tas, Vic)	5 to 1
12	Column (ACT, NSW, Qld, SA, Tas, Vic) Dozen (ACT, NSW, Qld, SA, Tas, Vic). 1-12, 13-24 or 25-36	2 to 1
18	Low (1-18), High 19-36, Even (Excludes zero!), Odd, Red, Black. (ACT, NSW, Qld, SA, Tas, Vic)	1 to 1

* The name four-line doesn't appear in the relevant diagram in the Tasmanian legislative instrument, but it appears to be a bet on the numbers 0,1,2,3. One of the Tasmanian casinos refers to this bet as "First four".

Victoria also allows "French Roulette" where all the above bet names are replaced by French equivalents. Since the relevant casino's web site does not indicate this version as being offered, the names have not been included in the above table.

In terms of the probability of winning, the payout odds and the expected return, all that matters is the value of *n*. We don't care which particular numbers are involved.

In this question we will determine general expressions for a standard bet that involves *n* winning numbers.

(a) Determine the probability that a bet involving *n* winning numbers wins.

(b) We noted in Q1(c) that the single number bet and the "Red" and "Black" bets would be "fair" if there were only 36 slots on the wheel, assuming that the slot removed was one of the non-winning numbers. In fact this property holds for all the "standard" bets in Roulette. The payout odds for a bet involving *n* winning numbers wins are those that would result in a fair game if the wheel had only 36 slots, *n* of which are winning.

Determine the payout odds for a bet involving *n* winning numbers. (Hint: Let the payout odds be *x* to 1 and construct an equation for the expected return.) Use your formula to verify that the payout odds given in the above table are correct.

(c) Determine the expected profit for a \$1 bet involving *n* winning numbers on a 37 slot wheel. What is unusual about your answer?

(d) Perhaps surprisingly, when Roulette is played on a 38 slot wheel (involving the extra "Double Zero" slot), the payout odds are identical to those given in the above table. Determine the expected profit for a \$1 bet involving *n* winning numbers on a 38 slot wheel.

Question 4 - Neighbours

Neighbours is a "five piece wager". That is, the stake for a "Neighbours" bet must be 5 times a legal amount for a standard bet. The normal way to achieve this is to bet 5 chips of equal value. If the minimum amount for a standard bet is \$1, the minimum amount for a Neighbours bet would be \$5.

A \$5 Neighbours bet on the number 19 is composed of 5 separate \$1 single number bets. These 5 bets are on the five adjacent numbers on the wheel of which 19 is the middle number. The order of the numbers on the wheel is standardised, so a Neighbours bet on 19 uses the same 5 numbers in every casino, but for the purpose of mathematical analysis of the bet, it doesn't matter which 5 numbers they are. The expected return would be the same for any bet that involved \$1 being bet on each of 5 different numbers.

Note that at most 1 of the 5 bets inherent in a Neighbours bet can win. If a \$5 Neighbours bet does win, it is split into the 5 \$1 bets it represents. Since 4 of these lose, \$4 of the stake is immediately lost. The other \$1 which won is returned to the player, along with the winnings appropriate for a \$1 straight-up bet.

(a) What is the probability that a Neighbours bet wins, meaning the ball lands in one of the 5 slots covered by the Neighbours bet?

(b) Use the probability from (a) to find the expected profit for a \$5 neighbours bet. Express it as a proportion of the \$5 outlay. What do you notice?

(c) An easier way to determine the expected profit of a neighbours bet is to note it is the sum of the expected profits of each of the 5 straight up bets that it combines. Use this method to verify the answer from (b).

Combination Bets

A combination bet combines two or more of the standard bets examined in the first 3 questions. The neighbours bet examined in the previous question is the simplest such bet available at most casinos.

The following table lists the combination bets allowed by legislation. A reference to "10/11" means a split bit on those numbers, while "25/26/28/29" is a corner bet on those numbers. As for the standard bets, names vary by location, with some locations using more than one name. The ACT allows the use of the traditional French names for these bets. The numbers involved in each bet may seem somewhat random, but usually they involve adjacent numbers on the wheel.

Name	Size of bet	Standard bets involved.
Neighbours (ACT, NSW, SA) Voisins (ACT)	five units	Single number bet on each of five adjacent numbers centred on the chosen number.
Chinese Horoscope bets (NSW)	three units	Single bet on each of three adjacent numbers.
Series 5/8 – Tier (NSW) Serie 5/8 – Tier (ACT)	six units	5/8, 10/11, 13/16, 23/24, 27/30 and 33/36
Orphans (ACT, NSW) Orphelins (ACT)	five units	1, 6/9, 14/17, 17/20 and 31/34
Grand Series 0/2/3 (NSW) Serie 0/2/3 – Voisin de Zero (ACT)	nine units	One piece on each of 4/7, 12/15, 18/21, 19/22, 32/35 and two pieces on 25/29 and 0/2/3.
Zero Game (ACT, NSW) 0-Spel (ACT)	four units	0/3, 12/15, 26 and 32/35;
Maxbet (NSW, Tas)	Varies	See below

In the ACT legislative instrument, the description of the "Serie 0/2/3" bet does not identify two of the sub-bets as each being two units. Presumably this is a drafting error, since it is still identified as a nine piece wager.

The above is a list of the combination bets allowed by the legislation, but there are no requirements for the casinos to offer the bets. It seems these bets are less common than the above table suggests. Based on the web sites of the relevant casinos:

- In ACT, they don't appear to be offered.
- In NSW, they only appear to be offered in Rapid Roulette, the version allowing computerised betting. The Chinese Horoscope bet does not appear to be offered.
- In SA, they do not appear to be offered.
- Victoria is complicated. The legislative instrument only seems to allow these bets for traditional roulette and not Rapid Roulette. The casino web site suggests they aren't offered for traditional roulette. However, the casino web site includes a picture of an ATS (Automated Transaction Station) that has buttons for "Tiers", "Orphelins", "Grand Series" and "Neighbours", but these bets don't appear in the accompanying list of allowed bets. Status unclear.
- Tasmania is also complicated. The legislative instrument states 'The permissible wagers for the game of Rapid Roulette shall be those wagers defined in diagram "A" and where the applicable button is provided on the ATS screen, those additional wagers as shown on Diagram "C".' The extra bets included in Diagram C are "Tiers", "Orphelins", "Grand Series" and "Neighbours", but the legislative instrument doesn't define these bets! It does however define Maxbet, which doesn't appear in any of the diagrams. The web site of one of the two Tasmanian casinos

includes an image of an ATS with the bets from Diagram C, but they don't appear in the list of bets the casino allows. Status unclear.

Maxbet

The player nominates a number. A $1 maxbet combination involves

- $1 straight-up on the number
- $2 on each available split bet involving the number
- $3 on the street bet involving the number
- $4 on each corner bet involving the number
- $6 on each six-line involving the number

The number of each type of sub-bet may vary with the chosen number. For example, the number 17 is roughly in the middle of the betting layout and occurs in 4 split bets, but the number 18, on the edge is in only 3 split bets, and 36 in the corner is in only 2 split bets. This makes Maxbet a complex bet to administer, so it is not surprising that in the states where it is offered by casinos, it is only offered via computerised betting.

As an example, if the chosen number is 17, the bets for a $1 maxbet are

- $1 straight-up on 17
- $2 on each of the splits (14/17, 16/17, 17/18 and 17/20),
- $3 on the street (16-18)
- $4 on each corner (13/14/16/17, 14/15/17/18, 16/17/19/20 and 17/18/20/21),
- $6 on each six line (13-18 and 16-21).

Hence the outlay is $40.

Question 5 – Combination Bets

Earlier, we found that the expected profit on any $1 standard bet is $-\$\frac{1}{37}$. The choice of unit is arbitrary, so for any standard bet, the expected loss is $\frac{1}{37}$ of the outlay. In the previous question the expected loss for a Neighbours bet was also found to be $\frac{1}{37}$ of the outlay. This result holds for all combination bets, a result you can prove if you are familiar with the theorem

$$E\left(\sum_{i=1}^{n} X_i\right) = \sum_{i=1}^{n} E\left(X_i\right) \text{ for positive integer } n.$$

which is the theorem that justifies the approach of Question 4(c).

(a) If you are comfortable with this theorem, use it to prove the expected loss on a combination bet is $\frac{1}{37}$ of the outlay. Note that some combination bets combine different sizes of bet, so consider a general combination bet that combines bets of $\$a_i$ on bet i, for $i = 1, 2, 3, ..., n$.

If you aren't familiar with the above theorem, you can still determine the expected return for each bet individually as done in Q4(b). This is a horribly tedious exercise, but for those who want to attempt it, here they are. In you couldn't follow the proof in (a), hopefully the following examples provide some evidence that the property does hold in general.

Determine the expected profit as a proportion of the outlay for:

(b) A $3 Chinese Horoscope bet.

(c) A $6 Series 5/8 bet.

(d) A $5 Orphans bet.

(e) A $9 Grand Series 0/2/3 bet.

(f) A $4 Zero Game bet.

(g) A maxbet on the number 17 as described above. ($40 outlay)

Question 6 – A stray 38 slot wheel bet

The legislation for ACT, NSW and Victoria allows the use of a 38 slot wheel, though none of the relevant casinos have taken up this option. The 38 slot wheel allows an extra type of bet not available on the 37 slot wheel. It is a bet on the 5 numbers, 0, 00, 1, 2, 3. The bet is called "Five-line", but in NSW the name "Five numbers" is also used.

(a) Determine the probability that this bet wins.

(b) The payout odds are 6 to 1. Determine the expected profit for a $1 five-line bet.

(c) In earlier questions we stated that the payout odds for standard bets would be fair odds for a wheel with only 36 slots. Show that this bet doesn't follow this pattern. Why doesn't it follow the pattern?

Question 7 – Triplestar (NSW only)

This is a bet which depends on multiple consecutive spins of the wheel. The relevant legislation states:

"3.5 Where the Triplestar option is offered, players may only place their wagers on the single star symbol on the layout. Where the same number is spun twice consecutively the dealer shall move the wager to the double star symbol where it will remain until the result of the third consecutive spin is determined. Wagers on the Triplestar option shall:

3.3.1 win if the same number is spun two times consecutively, otherwise shall lose; and

3.3.2 win if the same number is spun three times consecutively, otherwise shall lose."

Later, the payout odds are stated to be:

- number spun two times consecutively: 5 to 1
- number spun three times consecutively: 1000 to 1

The subsections of section 3.5 have been numbered 3.3.1 and 3.3.2 where they should be 3.5.1 and 3.5.2. (It seems that in the Gazette entry making the amendments that implemented that particular bet, the section numbers are correct, but a problem occurred in the production of the consolidated version of the approved rules.)

If the number is spun two times consecutively but not three times consecutively, clause 3.3.1 says the bet wins and clause 3.3.2 says it loses. Confusing, isn't it. Later, the approved rules indicate the order in which the casino employee should process the bets placed.

"5.5.4.1 where the winning number is not the same number as the previous winning number:

5.5.4.1.1 collect all Triplestar wagers on the layout;

5.5.4.1.2 collect all other losing wagers on the layout and proceed to pay all winning wagers.

5.5.4.2 where the winning number is the same number as the previous winning number:

5.5.4.2.1 move any wagers on the double star symbol to the triple star symbol;

5.5.4.2.2 move any wagers on the single star symbol to the double star symbol;

5.5.4.2.3 collect all losing wagers on the layout;

5.5.4.2.4 pay all winning wagers as defined in rule 3.2;

5.5.4.2.5 pay all winning wagers on the triple star symbol and return the original wager to the player;

5.5.4.2.6 pay all winning wagers on the double star symbol."

This is less ambiguous, but given the earlier confusions, it is safer to seek confirmation from the casino's web site. The casino's web site suggests this bet is only offered on the traditional roulette tables and not on the Rapid Roulette system. The casinos brochure states:

"For example: if number 7 is the first winning number, the dealer will place a Triplestar button on number 7 on the layout to denote the number has been spun once. You may then place a wager on the Triplestar area of the layout if you think that number 7 will be repeated twice more consecutively.

If number 7 is the next winning result ie. two times in a row; your Triplestar wager will be moved by the dealer to the double star symbol on the layout and you will be paid odds of 5 to 1. Your original Triplestar wager must remain on the layout for the next spin. The dealer will place a Triplestar button on number 7 to denote that number 7 has been spun twice in a row.

If the number 7 is the next winning result ie. three times in a row; the dealer shall move your wager to the Triplestar symbol on the layout and you will be paid at odds of 1,000 to 1 and your original wager will be returned to you."

This seems to confirm that:

- If the 7 occurs *only* 2 times in a row, winnings are paid at 5 to 1, but the gambler's stake is lost.
- If the 7 occurs 3 times in a row, winnings are paid at 5 to 1 after the second occurrence and a *further* 1,000 to 1 on the 3rd occurrence, giving a total of 1,005 to 1, and the stake is returned.

(a) If 7 was the last number obtained, determine the probability that 7 wins only twice in a row and the probability that it wins 3 times in a row.

(b) Determine the expected profit for a $1 triplestar bet.

Question 8 – Double, Treble and Quad (Victoria only)

The Victorian legislation only allows these bets in Rapid Roulette. The relevant casino's web site suggests that they are not offered, but we will analyse them anyway, since they are conceptually different to the other bets analysed above.

These are multi-spin bets, but they have an important difference to the triplestar bet of the previous question. In a triplestar bet, the gambler does not choose a number. Rather, the gambler is betting that the number obtained on the last spin will happen again on the next spin, and ideally on the next two spins. By contrast, in these bets the gambler chooses a number, and is betting that number will occur on (ideally) the next two, three or four spins, with smaller payouts occurring for smaller numbers of spins.

The bets are defined as follows in the relevant Victorian legislative instrument.

"7.4 The bets which can be placed in respect of a spin sequence and the odds payable for them are –

Name	Definition	Odds
Double	Player designates "Straight-Up" outcomes of each of two consecutive spins– • If first spin, but not second spin, designated outcome occurs • If all designated outcomes occur	 25 to 1 375 to 1

Treble	Player designates "Straight-Up" outcome of each of three consecutive spins– • If the first spin, but not second or third spin, designated outcome occurs • If first and second spin, but not third spin, designated outcome occurs • If all designated outcomes occur	 25 to 1 250 to 1 5000 to 1
Quad	Player designates "Straight-Up" outcomes of each of four consecutive spins– • If first spin, but not second, third or fourth spin designated outcome occurs • If first and second, spin but not third or fourth spin, designated outcome occurs • If first, second and third spin but not fourth spin, designated outcome occurs • If all designated outcomes occur	 12½ to 1 125 to 1 12,500 to 1 500,000 to 1

(a) To paraphrase the above, in the bet known as "Double" if the players chosen number occurs on:

The first (next) spin, but not second spin, winning are paid at 25 to 1.

Both of the next two spins, winnings are paid at 375 to 1.

In both the above cases, the stake is also returned. If the chosen number does not occur on the first spin, the stake is lost.

Determine the expected profit for a $1 "Double" Bet.

(b) The definition of Treble includes a rather odd feature. If the player's chosen number occurs on the first and third throw but not the second, the player loses.

Determine the expected profit for a $1 "Treble" Bet based on this literal interpretation. Hint: Once there are multiple losing cases, as in this scenario, it can be simpler to regard the $1 stake as lost in all cases, and then adjust by regarding it as additional winnings in the winning cases.

(c) The odd feature described in (b) is possibly a legislation drafting error. It seems unreasonable that the occurrence of the chosen number should ever be unfavourable to the gambler. Perhaps the first bullet point in the definition of this bet should read:

"If the first spin, but not second spin, designated outcome occurs".

Determine the expected profit for a $1 "Treble" Bet based on this alternative definition.

(d) The definition of Quad includes similar oddities to treble, but with more separate cases to track.

Determine the expected profit for a $1 "Quad" Bet based on the literal interpretation. The hint from (b) is again useful.

(e) As for Treble, it is possible that the definition of Quad contains a drafting error. (If nothing else, it seems to have a misplaced comma in the second bullet point.) It is plausible to suggest that the first bullet point should read

"If the first spin, but not second spin, designated outcome occurs".

and the second should read

"If first and second spin, but not third spin, designated outcome occurs".

Determine the expected profit for a $1 "Quad" Bet based on this alternative definition.

Note – Victorian Jackpots

The Victorian rules for Rapid Roulette allow the payment of additional "jackpot" prizes. The allowed structures are very general, and thus aren't conducive to meaningful mathematical analysis. The casino concerned does use the presence of jackpots as a marketing tool, but the information supplied on their web site is too vague to allow any mathematical analysis. We can say that the presence of jackpots will reduce the gambler's expected loss, but the reduction may well be negligible.

Jackpot systems often involve keeping running totals of the amounts bet by all gamblers, so they are only suited to games where bets are made on a computerised betting system, such as Rapid Roulette. Jackpots systems may be spread across several "Rapid" games. Presumably the aim of this is to induce gamblers to make more bets. A Rapid Roulette gambler who hears regular announcements about jackpots being won may assume that the winner must have been one of the 10 or so players at that particular game of Rapid Roulette, and that he or she has a "good" chance of winning the next jackpot. In reality it could have been any of several hundred players in separate areas of the casino playing different games of Rapid Roulette, or even computerised games other than Roulette. Hence the gambler's chance of winning the jackpot is probably negligible.

Revision History

Version 0.1 Beta release. 17/11/2007

Version 0.2 Beta release. 18/11/2007. Fixed typo in final note on Victorian Jackpots.

Version 0.3 Beta release. 25/11/2007. Fixed typo in Q1(c) and first paragraph of Q3.