

House Rules

- 1. 1 deck.
- 2. Blackjack pays 3:2.
- 3. Dealer stands on soft 17.
- 4. No resplitting.
- 5. Double down any 2.
- 6. Double down after splitting allowed.
- 7. 1 card dealt on split aces.
- 8. No insurance.
- 9. No surrender.

Our aim is to find the optimal strategy for the popular casino game Blackjack. The strategy is found by using a reinforcement learning algorithm known as Q-learning. The code to achieve this can be found at my[GitHub](#).

Before we continue we need to understand how card counting works. We use the most common card counting system, the Hi-Lo count. The system works by adjusting the card count everytime you observe a new card. You add 1 to the count if the card is a 2, 3, 4, 5 or 6. You minus 1 if the card is a 10, Jack, Queen, King or ace. The count remains the same if the card is a 7, 8 or 9. Our approach is unique to most in that we try to find the best strategy for when the count is negative, when it is positive and when it is 0. Here we just show the strategy when the count is 0.

	Hard total													Soft total									
Dealer's card	5	6	7	8	9	10	11	12	13	14	15	16	17+	13	14	15	16	17	18	19	20+		
2	Hit	Hit	Hit	Hit	Hit	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Stand	Stand		
3	Hit	Hit	Hit	Hit	Hit	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Stand	Stand		
4	Hit	Hit	Hit	Hit	Hit	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Stand	Stand		
5	Hit	Hit	Hit	Hit	Hit	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Stand	Stand		
6	Hit	Hit	Hit	Hit	Hit	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Stand	Stand		
7	Hit	Hit	Hit	Hit	Hit	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Stand	Stand		
8	Hit	Hit	Hit	Hit	Hit	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Stand	Stand		
9	Hit	Hit	Hit	Hit	Hit	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Stand	Stand		
10	Hit	Hit	Hit	Hit	Hit	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Stand	Stand		
A	Hit	Hit	Hit	Hit	Hit	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Hit	Hit	Hit	Stand	Stand	Stand	Stand	Stand		

Card to split										
Dealer's	2	3	4	5	6	7	8	9	10	A
2	Hit	Hit	Hit	Stand	Hit	Hit	Hit	Hit	Stand	Hit
3	Hit	Hit	Hit	Hit	Hit	Hit	Hit	Hit	Stand	Hit
4	Hit	Stand	Hit	Stand	Hit	Hit	Hit	Hit	Stand	Hit
5	Hit	Hit	Hit	Stand	Hit	Hit	Hit	Hit	Stand	Hit
6	Hit	Hit	Hit	Stand	Hit	Hit	Hit	Hit	Stand	Hit
7	Hit	Hit	Hit	Stand	Hit	Hit	Hit	Stand	Stand	Hit
8	Hit	Hit	Hit	Hit	Hit	Hit	Hit	Stand	Stand	Hit
9	Hit	Hit	Hit	Hit	Hit	Hit	Hit	Stand	Stand	Hit
10	Hit	Hit	Hit	Hit	Hit	Hit	Hit	Stand	Stand	Hit
A	Hit	Hit	Hit	Hit	Hit	Hit	Stand	Stand	Stand	Hit

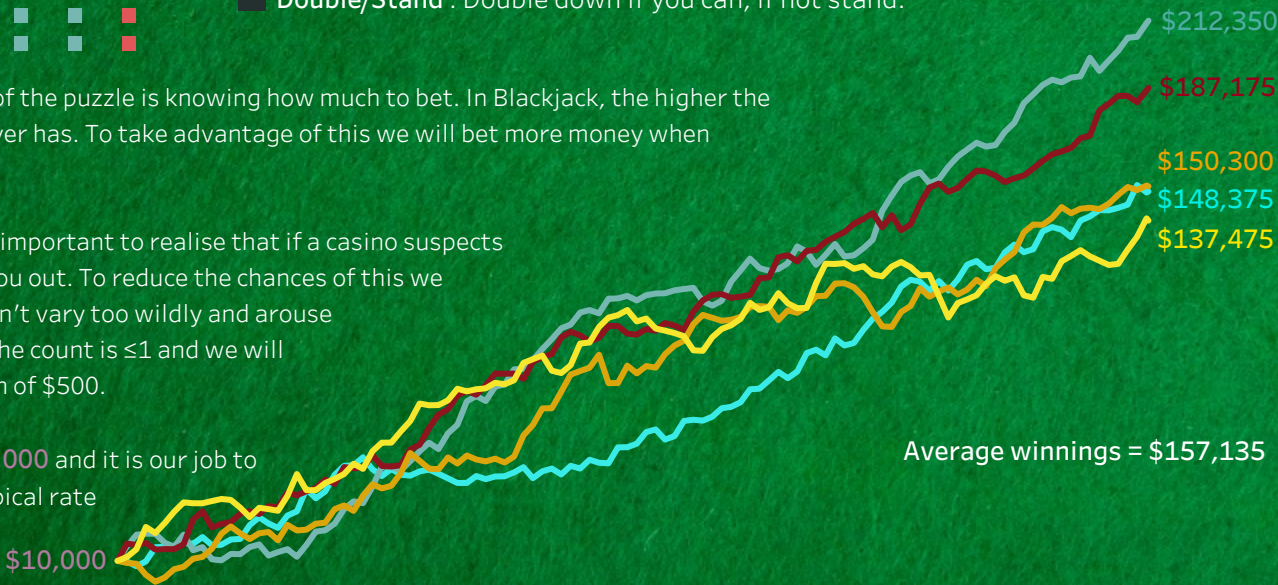
Action

- Hit : Take another card from the dealer.
- Stand : Don't take any more cards.
- Split : If your first 2 cards have the same value, split them into 2 hands.
- Double/Hit : Double down if you can, if not hit.
- Double/Stand : Double down if you can, if not stand.

Now we have a playing strategy, the last piece of the puzzle is knowing how much to bet. In Blackjack, the higher the card count is, the more of an advantage the player has. To take advantage of this we will bet more money when the card count is higher.

Before we devise an exact betting strategy it is important to realise that if a casino suspects you are card counting, they will probably kick you out. To reduce the chances of this we will set a min and max bet to ensure our bets don't vary too wildly and arouse suspicion. We will bet a minimum of \$50 when the count is ≤ 1 and we will bet $\$(count * 50)$ for a count ≥ 2 , up to a maximum of \$500.

Let's pretend we have an initial bankroll of \$10,000 and it is our job to play Blackjack with this strategy. Let's say a typical rate of play is 60 games/hour and a typical work week is 35 hours. Then in a year we would play $60 * 35 * 52 = 109,200$ games. Now let's run 5 individual simulations of 109,200 games to see how this plan might work out.



As we have seen, the average annual winnings by using our strategy is \$157,135. To put this into perspective, let's compare this value with the national average salary of a variety of different jobs in the USA in 2021.

Theoretical gambler	\$157,135
Quantitative analyst	\$153,539
Data scientist	\$121,673
Software engineer	\$106,119
Mathematician	\$100,351
Economist	\$98,716
Nuclear engineer	\$91,119
Psychologist	\$86,181
Statistician	\$84,336
Chiropractor	\$65,201

Source: <https://www.indeed.com/career-advice/finding-a-job/top-100-highest-paying-jobs>