Game Rules GBG

NOTE: When starting GBG from JAR (**GBGLaunch.jar**), the display of HTML sources will only show the base HTML file, not any subsequent resources (images, formulas). To show all elements, use either PDF display, which is always in *one* file, or start GBG from Java sources.

2048

1-player game.

The game starts with game score 0 and two tiles with value '2' or '4' placed randomly on the otherwise empty 4x4 game board. Whenever the player makes an action, the environment adds a random tile '2' (90%) or '4' (10%) in one of the cells being empty after the player's action.

The player has at most these four actions: LEFT, UP, RIGHT, DOWN. An action is only **legal** if it moves at least one tile. If the player chooses LEFT, all tiles are moved to the left until they are adjacent to another tile. If now in a row two adjacent tiles have the same number 'X', the leftmost pair of those is merged to a new tile '2X'. In Figure 1, if a LEFT action is triggered, the 1st row gets the two leftmost '8's merged into one '16'. In the 2nd row the two '2's are merged into one '4'.

Whenever two tiles are merged, the merged value is added to the **game score**.

Figure 1: Intermediate position in the game 2048. The possible legal actions are LEFT, RIGHT and DOWN. The action UP is not legal since it would not move a single tile

The game **ends** if no legal move is possible (all cells filled and no merge possible).

The first goal of the game is to reach the '2048' tile. But beyond this, the broader goal is to reach even higher tiles and the highest possible game score.

Connect Four

2-player game.

Each player in turn places a piece of his/her color on the (6 rows x 7 columns)-board. The pieces fall in each column down to the lowest empty cell.
Yellow (X) starts.

The player who gets four-in-a-row (horizontal, vertical or diagonal) wins. If no player reaches this and no moves are left, it is a tie.
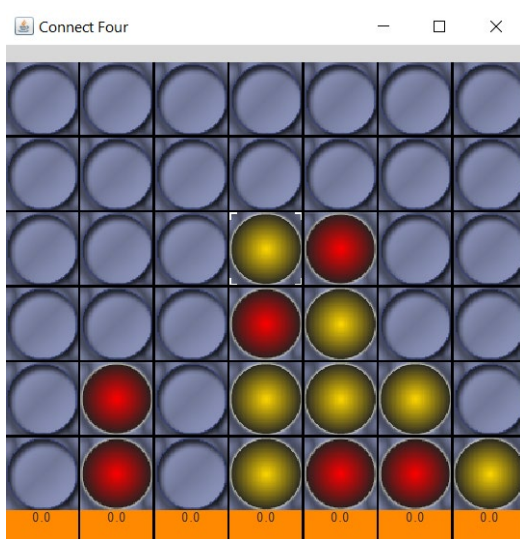

Figure 2: Yellow (X) wins in Connect Four.

EinStein würfelt nicht! (EWN)

2-, 3- or 4-player game.

"EinStein würfelt nicht!" (EWN) is a non-deterministc board game for up to 4 players.
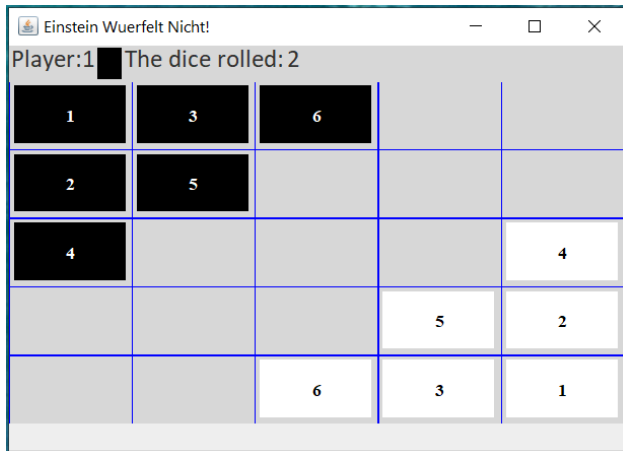

Figure 3: EWN starting position in the 5x5 (6 tokens, 2 players) variant.

In the most popular variant the game is played by 2 players on a 5x5 board and each player has 6 tokens. But other variants exist as well:
- 3x3 board (3 tokens, 2 players)
- 4x4 board (3 tokens, 2 players)
- 5x5 board (3 tokens, 2 players)
- 6x6 board (6 tokens, 3 players)
- 4x4 board (3 tokens, 4 players)
- 6x6 board (6 tokens, 4 players)

Game rules

Popular variant (5x5, 2 players): Each player starts with 6 tokens numbered from 1 to 6 accordingly. Each player has to roll the dice in order and move the token with the matching number rolled in the direction of the opposite corner. Moving back is not allowed. Capturing own tokens and enemy tokens is allowed and can offer a decisive advantage. Should the dice show a number that is not available, then the player can select the next higher or lower token. A rollover from 6 to 1 or 1 to 6 is not possible. The fewer tokens a player has, the higher is their selection probability. This increases the mobility of these tokens.

2-player variant

The 2-player variant is played on a 5x5 game board and the starting positions are diagonally opposite to each other. To win the game one player must capture all enemy tokens or reach the opposite corner (starting position of the enemy).

3-player variant

The 3-player variant is played on a 6x6 board. Player 1 and 2 form a team and place their tokens directly opposite to each other. The third player places his/her tokens in one of the free corners. The winning condition is slightly different. If one player loses all his/her tokens his/her team has lost. The solo player 3 has another win condition by reaching the empty corner with one token.

4-player variant

The 4-player variant is played on a 6x6 game board. Each two players in opposite corners build a team. The winning situation is similar to the 2-player variant. As soon as one team player reaches the opposite corner her/his team won. If, on the other hand, one team member has lost all its tokens, her/his team has lost.

Hex

2-player game.

Scalable game with scalable parameter N = side length of board.

The game board is a diamond with side length N of hexagonal cells. Two adjacent rims of the diamond are colored black, the other two white. Each player in turn places a piece of his/her color on a free cell.
Black (X) starts.

The player who forms a connected line of his/her color between the adjacent rims of his/her color **wins** the game. Hex **cannot** end in a tie.
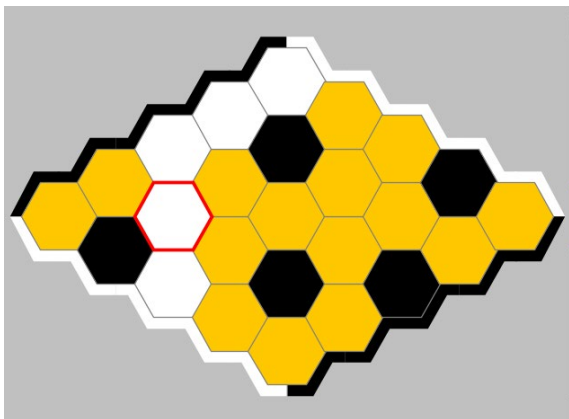

Figure 4: White wins in 5x5 Hex

Nim

2-player game.

Scalable game with three scalable parameters: (a) number of heaps N, (b) size of each heap S (number of items), (c) maximum number of items to take in one move ("Max Minus") M.

The game starts with N heaps of size S. Each player in turn takes away 1,2,…,M items from **one** heap. Black (X) starts.

The player who takes away the last item **wins** the game.
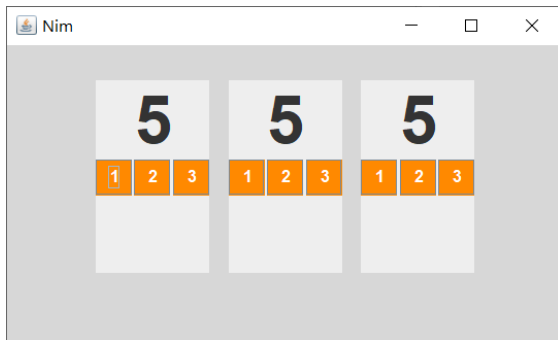
Nim **cannot** end in a tie.

Figure 5 Starting position for Nim: N=3 heaps of size S=5, Max Minus = 3.

Nim3P

3-player game.

Same game layout (see Figure 4) and same move rule as for Nim. Scalable parameters: (a) number of heaps N, (b) size of each heap S (number of items), (c) whether the extra rule is active or not. The maximum number of items to take from each heap ("Max Minus") is in Nim3P always M=S.

Now three players P0, P1, P2 move in turn and take items away.
P0 starts.

Win rule: The player **who follows** the player taking the last item is the player who wins. He/she gets a reward 1, both others get reward 0.

Extra rule (optional): If scalable parameter "Extra Rule" is set to true, then the player who follows the winning player gets an extra reward of 0.2. This helps to break ties for otherwise 'undecided' states.

Nim3P **cannot** end in a tie.

Othello (Reversi)

2-player game.

This game is played on a 8x8 board. The start position has two white pieces and two black pieces in the center. Each player in turn places a piece of his/her color on the 8x8 board. Placement can be only made in those empty cells that enclose – with a help of another piece of the player – one or more opponent pieces (see Figure 4: the green rectangles mark the legal moves). All enclosed opponent pieces have their color reversed to the player's color. Black (X) starts.
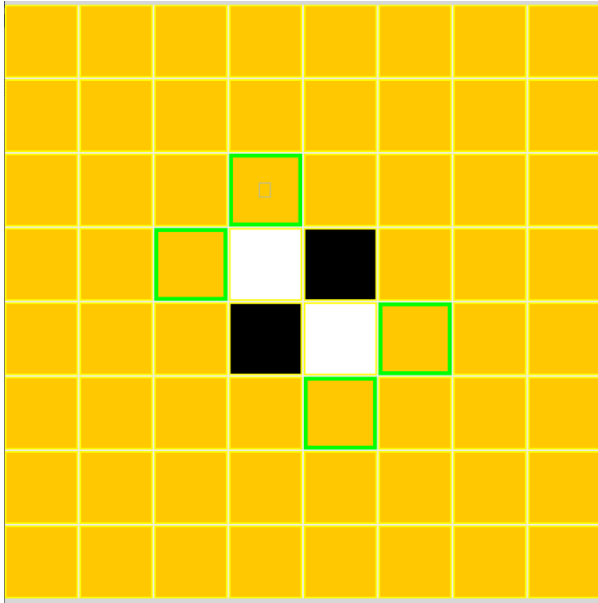
Figure 6 Starting position for Othello. Black starts and the green rectangles mark his/her legal moves.

If a player cannot make a legal move, he has to pass and the opponent moves again. If both players cannot move, the game is over. The player with the most pieces on the board **wins**. If both players have an equal number of pieces, it is a tie.

Rubik's Cube

1-player game.

(in preparation)

Sim

2- or 3-player game.

Scalable game with these scalable parameters: (a) K = number of nodes and (b) P = number of players (2 or 3).

The game board is a complete graph with K nodes. Each player in turn colors a free edge of the graph with his/her color.
Black (X) starts.

The player who completes a monochromatic triangle of his/her color **loses**. In the 2-player variant, the opponent is the winner, in the 3-player variant the two opponents continue to play until one of them also loses. If two or more players do not complete a triangle when the graph is completely colored, it is a **tie**. In the 3-player variant there are two kinds of a tie: (a) a tie between all players or (b) one player loses and it is only a tie between the remaining two opponents.

It is known from Ramsey theory that for $K \geq K_0$ with $K_0 = 6$ (2 player) and $K_0 = 17$ (3 player) the game **cannot** end in an all-player tie. But for smaller $K < K_0$ the game is likely to end in a tie.
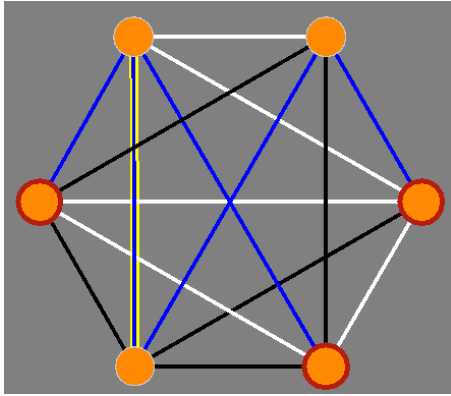
Figure 7: White loses in 3-player Sim with K=6 nodes. The last move (marked by yellow bar) of Blue does not close a monochromatic triangle, so it is a tie between Black and Blue.

Within the 3-player variant we allow additionally two *Coalition* variants:

- *Coalition = None*:   all 3 players play for their own, or
- *Coalition = 1-2*:   players 1 and 2 form a coalition against the third player 0 who plays alone.

Tic Tac Toe

2-player game.

Each player in turn places a piece of his/her color on the 3x3 board.
Black (X) starts.

The player who gets three-in-a-row (horizontal, vertical or diagonal) **wins**. If no player reaches this, it is a tie.

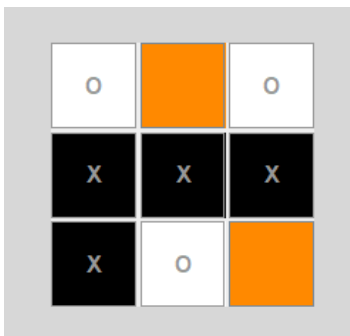*Figure 8: Black (X) wins in Tic Tac Toe.*

Yavalath

2- or 3-player game.

It's played on a hexagonal board with a side length of 5 tiles. White starts and then the players take turns placing a tile on the board. The first person to get four-in-a-row without first getting three-in-a-row wins the game. Placing three-in-a-row loses the game. If the board is all filled up without a winner, the match is a draw.
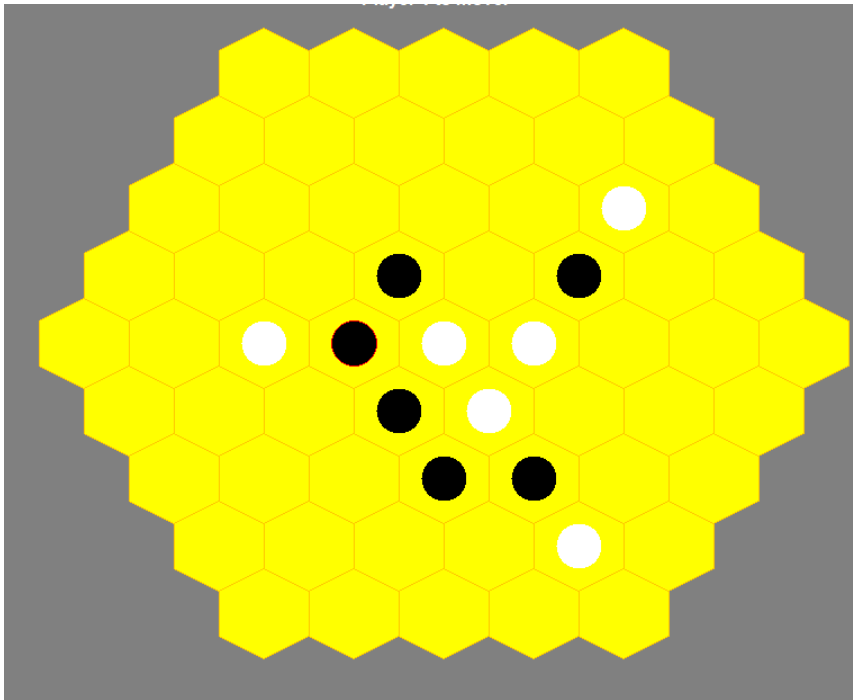
Figure 9: Black loses the game after being forced to respond to the threatening move of white.

SWAP RULE (2-PLAYERS ONLY)

In the 2-player version, the 2nd player can choose, *only after the 1st move of the 1st player*, to swap colors. This is to mitigate the advantages of a strong opening move chosen by the first player.

3-PLAYER-RULES

The 3-player-version of Yavalath has two extra rules:

- If a player loses by placing three-in-a-row, they are removed from the game, while their game pieces remain on the board.

- If the next player can win by placing four-in-a-row, the current player *must* block that move.

Poker

2-player game (in GBG).

Poker is a game with a high number of different variants (e.g. five-card draw, community card poker, …) and different house rules specifying the detailed parameters of the game. Because of this, the following paragraphs won't cover all possible options but will focus on the implemented game mechanics.

How many players are part of the game?

Poker is a multiplayer for 2-10 players depending on the chosen variant. In GBG, we have only the 2-player variant implemented.

How to win the game?

Anyone who has lost all of their chips is knocked out of the game. The last remaining person is the winner.

How is the game played?

The game is played with a deck of 52 cards. Every player gets the same amount of chips. The dealer is the first player of the group. After the initial setups there are as many rounds played until there is only one remaining player.

How is a game round structured?

A game round can be structured into six different phases:

- **Setup:** The first player next to the dealer is placing the *small blind* and the player after that placing the *big blind*. These are forced bets and the players do not have the option to pass or fold at this step. The *big blind* is equal to the *minimum bet* and the *small blind* is half of the big blind. (In many tournament settings the *small* and *big blind* are increasing over time to create more action in the game. In this implementation, small and big blind stay constant over time.) After the blinds are placed every player gets two cards which are referred to as *hole-cards*. The hole cards are only visible and accessible to the respective player.

- **Pre-Flop:** After the hole cards are dealt there is a first betting round.

- **Flop:** Three community cards referred to as the *flop* and available to each player are revealed. After this new information there is a second betting round.

- **Turn:** Another community card referred to as the *turn* and available to each player is revealed. After this new information there is a third betting round.

- **River:** Another community card referred to as the *river* and available to each player is revealed. After this new information there is a fourth betting round.

- **Showdown:** During the showdown the winning hand is determined and the pots are awarded to the respective winner(s).

After the showdown a new game round starts and each player with remaining chips can participate again.

Betting round: Each player chooses an *Action* until every player has either matched the placed bets or folded.

Actions

- **Check:** If there are no bets placed in the current round, the active player has the option to *check*. With this he declines to makes a bet but still remains in the game. If all players are *checking* the betting round may end without a bet and the game will move to the next stage.

- **Bet:** If there are no bets placed in the current round the active player has the option to make a bet. In the implemented version the size of the bet is predefined as the [minimum bet](). If the active player has not a sufficient amount of chips to place a bet he will be forced to go *all in* if he chooses to bet. With this the size of the bet is equal to the amount of chips the player has available.

- **Fold:** A player has always the option to *fold*. With this the active player drops out of the current game round and cannot make any further actions and does not receive any chips at showdown.

- **Call:** If a bet has been placed, the active player has the option to *call* the existing bet. With this he places the same amount of chips as the size of the bet.

- **Raise:** If a bet has been placed, the active player has the option to *raise* the existing bet. With this he increases the betted amount by the [minimum bet](#).

- **All In:** If a player goes *all in*, all remaining chips of the active players are bet. If a player is *all in*, he cannot make another action during this game round. This might result into a *split pot* because the active player might not be eligible for the complete Pot. For example: Player A and Player B are betting 100 chips each, resulting in a pot of 200. Player C has only 40 chips left and goes all in. Resulting in Pot_1: 3*4 = 120 chips where Player A, B and C are eligible and Pot_2: 2*60 =120 chips where only Player A and B are eligible because C didn't have sufficient chips.

Determine the winning hand

During the showdown the best five cards, out of the given seven (two hole-cards and the five community cards) are chosen. If there are two players with the same hand there are options to break the tie. If there are no options left to break the tie, the pot will be shared.

Hand	Definition	Tie break
Royal flush	A *straight flush* with an Ace as the highest card	-
Straight flush	Both a *straight* and a *flush*	The highest card in the straight flush breaks the tie.
Four of a kind	Four cards of the same rank	The highest rank of the four of a kind breaks the tie. If it is still a tie, the highest fifth card breaks the tie.
Full House	A three of a kind and a pair	The rank of the three of a kind breaks the tie. If it is still a tie, the highest pair breaks the tie.
Flush	All five cards with the same suit	The highest rank in the flush breaks the tie. If it is still a tie, the second highest rank breaks the tie.
Straight	All five cards in a continuous sequence. As a special case the ace can take the place of the lowest rank in a straight from ace to 5 as well as the highest rank in a straight from 10 to ace. A straight	The highest rank in the straight breaks the tie.

	"around the corner" e.g., Q-K-A-2-3 is not possible.	
Three of a kind	Three cards of the same rank	The rank of the three of a kind breaks the tie. If it is still a tie, the highest card breaks the tie. If it is still a tie the second highest card breaks the tie.
Two pair	Two pairs	The highest rank of the pairs breaks the tie. If it is still a tie, the second pair breaks the tie. If it is still a tie the highest card breaks the tie.
One pair	Two cards of the same rank	The rank of the pair breaks the tie. If it is still a tie, the highest card breaks the tie. If it is still a tie, the second highest card breaks the tie …
High card	The highest card	The rank of the highest card breaks the tie. If it is still a tie, the second highest card breaks the tie …

Kuhn Poker

2-player game.

Kuhn Poker is an extremely simplified version of poker. There are only three cards (J=Jack, Q=Queen, K=King) and each player gets exactly one card. Each player pays a blind of 1.

There is only one betting round, during which both players have the available actions Check, Bet 1, Fold, Call as described in Poker.

The winner is the one with the higher card. He gets the pot. (The pot contains 2,3 or 4, depending on the actions in the betting round.)

Black Jack

1-player game.

Black Jack is a popular card game that is played in many different variations depending on the country it is played in. In *General Board Game* the American variant is implemented. (The American variant is defined by the ability to *split* a pair up to three times, *double down* any hand consisting of two cards and *double down* a hand that has been split before. Also, the dealer *stands* on a soft 17 (e.g.: Ace of Spades and Six of Diamonds) and peeks for a natural Black Jack before the players have the ability to surrender (late surrender).)

How many players are part of the game?

Black Jack can be played by one up to seven players. The players play independent from one another against the dealer. The game is implemented in GBG as a **1-player game**, since the other players have no influence on the current player (at least not in the infinite-card-deck variant implemented here) and since the dealer acts deterministically, given the values of his randomly-filled hand.

Card-values

Every card in Black Jack represents a numeric value.

- An Ace either counts 1 or 11. As an example the hand *{Ace of Spades, Nine of Spades}* would count 20 (=11+9) whereas the hand *{Ace of Spades, Nine of Spades, Five of Spades}* would count 15 (=1+9+5).

- Kings, Queens and Jacks count 10

- All remaining cards count their rank, e.g. *Seven of Hearts* counts 7.

A hand with a certain count, e.g. 16, is said to be a **Hard 16**, if it does not contain any Ace counted as 11. Example: *{Nine of Spades, Seven of Hearts}*. A hand of 16 is said to be a **Soft 16**, if it does contain any Ace counted as 11. Example: *{Five of Spades, Ace of Hearts}*. A Soft 16 is more flexible: If another card is dealt, say a Ten, the new value is not 5+11+10 = 26, but 5+1+10 = 16. The new hand is now a Hard 16.

Win condition of hands

Every hand consists of at least two cards and represents a numeric value (hand-value). The hand-value of a hand is calculated by the sum of all numeric card-values the hand consists of. A hand whose hand-value is closer to, but not greater than 21 wins against another hand. Two hands with the same hand-value result in a tie (also known as push). If player and dealer both get a hand with a hand-value greater than 21 the player's hand loses.

Natural Black Jack

If a hand consisting of only two cards has a hand-value of 21 it is considered a natural Black Jack. A natural Black Jack wins against any other hand and ties against another natural Black Jack. An example for a natural Black jack would be the hand *{Ace of Spades, Queen of Hearts}*.

Moves/Actions

Bet: The player places a wager (requirement for getting a hand dealt)

Stand: The player passes to the next player or his next hand.

Hit: The player wants one more card dealt.

Double Down: Only allowed with a hand consisting of exactly two cards. The player is allowed to double the wager of his hand. He will get dealt exactly one more card and automatically passes to the next player or his next hand.

Split: A hand can only be split up to three times. It is only allowed with a hand consisting of exactly two cards with the same rank e.g.: *{Seven of Hearts, Seven of Diamonds}*.

The player needs to place the wager of the original hand again. The hand will get split which results in two hands. The hand *{Seven of Hearts, Seven of Diamonds}* will result in the hand *{Seven of Hearts}* and the hand *{Seven of Diamonds}*. The hand on which the split was

performed will get dealt one more card and will get played first. A natural Black Jack in a split hand is not considered a natural Black Jack.

Surrender: The players can only surrender their hands after the dealer peeked for a natural Black Jack. If the dealer does not have a natural Black Jack, the players are allowed to surrender their hands. They will get half of their wager back and stop playing until this round ends.

Insurance: A side bet with the same wager as the player's hand. The face up card of the dealer needs to be an *Ace*. If the dealer has a natural Black Jack, this side bet is won and pays 2:1.

How is a game round structured?

Before getting cards dealt, players have to place their wager. Every player and the dealer get two cards dealt. Players get their cards dealt face up. The first card of the dealer is dealt face up whereas the second card of the dealer is dealt face down. If the dealer's face up card is an *Ace* the dealer asks all players if they want to take insurance. If the dealer's face up card shows an *Ace, King, Queen, Jack* or a *Ten* the dealer will peek for a natural Black Jack. If the dealer has a natural Black Jack, no further actions of the players are allowed (in this case, it is not allowed to surrender anymore). If the dealer does not have a natural Black Jack, the round continues and players can choose between actions they are allowed to perform. After every player completes the turn, the dealer will play his hand. The dealer will always take cards (=*hit*) until his hand-value is greater or equal to 17 and he passes his turn afterwards (=*stand*). **The dealer stands on [Soft 17](#)**, meaning that the dealer stops even if the 17 (or higher) is formed with cards containing an Ace counting 11. After the dealer completes his hand, players get paid off. For this purpose, it needs to be identified, which of the player's hands won, lost or tied against the dealer's hand.

After every player is paid, all cards get removed from play and a new round begins.

Pay-out

If a player's hand loses against the dealer's hand, the wager of the player's hand is lost. If a player's and the dealer's hand tie the player gets the wager of his hand back (=*push*). If a player's hand wins against the dealer's hand, the player will get paid 1:1 and he also gets his wager back. Insurance pays 2:1. A Natural Blackjack pays 3:2.

A pay-out example of a player winning with a natural Black Jack who placed a wager of 100 chips: He will get his wager of 100 chips back and his pay-off of 100 * (3/2) = 150 chips in addition.