Game of Sticks

In the game of sticks there is a heap of sticks on a board. On their turn, each player picks up 1 to 3 sticks. The one who has to pick the final stick will be the loser.

The following is an example of the game of sticks.

- The game starts with 20 sticks on the board.
- Marvin takes 3 sticks, there are 17 sticks remaining.
- Hal takes 2 sticks, there are 15 sticks remaining.
- Marvin takes 1 stick, there are 14 sticks remaining.
- Hal takes 3 sticks, there are 11 sticks remaining.
- Marvin takes 2 sticks, there are 9 sticks remaining.
- Hal takes 2 sticks, there are 7 sticks remaining.
- Marvin takes 3 sticks, there are 4 sticks remaining.
- Hal takes 1 stick, there are 3 sticks remaining.
- Marvin takes 2 sticks, there is 1 stick remaining.
- Hal has to take the final stick and loses.

This assignment is split into three parts:

1. Implementing the game as a two-player game.
2. Adding an AI that can be played against.
3. Adding an option for training the AI against another AI.

Part one: Human vs. Human

First, create a game where two players can play against each other. The two examples below demonstrate how the game should behave.

Example 1

```
Welcome to the game of sticks!
How many sticks are there on the table initially (10-100)? 10

There are 10 sticks on the board.
Player 1: How many sticks do you take (1-3)? 3

There are 7 sticks on the board.
Player 2: How many sticks do you take (1-3)? 3

There are 4 sticks on the board.
Player 1: How many sticks do you take (1-3)? 3

There is 1 stick on the board.
Player 2: How many sticks do you take (1-3)? 1
Player 2, you lose.
```

Example 2

```
Welcome to the game of sticks!
How many sticks are there on the table initially (10-100)? 500
Please enter a number between 10 and 100
How many sticks are there on the table initially (10-100)? 3
Please enter a number between 10 and 100
How many sticks are there on the table initially (10-100)? 50

There are 50 sticks on the board.
Player 1: How many sticks do you take (1-3)? 3

There are 47 sticks on the board.
Player 2: How many sticks do you take (1-3)? 55
Please enter a number between 1 and 3
Player 2: How many sticks do you take (1-3)? 3

There are 44 sticks on the board.
Player 1: How many sticks do you take (1-3)? 3
...

There is 1 stick on the board.
Player 1: How many sticks do you take (1-3)? 1
Player 1, you lose.
```

Implement a game with the functionality described above.

Part two: Human vs. AI

Playing against your friends is nice, but you're studying computer science for a reason. We can learn to do some pretty cool stuff. So can the computers -- when taught. Let's create an AI for our game.

One way to create an AI for the game of sticks is to mathematically analyze the game and craft an AI based on the analysis. However, we now do the opposite. We create a learning AI that is able to learn a good strategy for the game of sticks by playing the game against us. After this, the mathematical analysis is easier to do because we already know how to play the game optimally.

Consider the functionality of the AI using the following description:

- An AI has a number of hats, one hat for each possible amount of sticks on the table. Initially, each hat contains three balls that are numbered from 1 to 3.
- At every step of the game that the AI plays, the AI takes a random ball out of the hat that matches the amount of sticks currently on the board. When the AI takes a ball out of a hat, it places it next to the hat for waiting, reads the number on the ball, and takes the amount of sticks that the ball indicates.
- If the AI wins the game, it puts two balls of the type to each hat that has a ball next to it. Both balls have the same number. If the AI loses, it will throw away the balls that are next to the hats. (Note: A hat must always have at least one ball of each number, hence the last ball of a specific number cannot be thrown away and must be put back to the hat)
- As more and more games are played, there will be more balls that indicate a good number of sticks to take. This means that as balls are taken at random, it becomes more likely that the AI is able to play well.

Consider an example where there are 10 sticks at the beginning.

The hat contents for the AI are as follows:

Hat	1	2	3	4	5	6	7	8	9	10
Content	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3

The game may proceed as follows:

1. Player takes 3 sticks, there are 7 sticks remaining.
2. AI randomly picks up ball 2 from the hat 7. This means that the AI takes 2 sticks, and there are 5 sticks remaining.
3. Player takes 1 stick, there are 4 sticks remaining.
4. AI randomly picks up ball 3 from hat 4. This means that AI takes 3 sticks, and there is 1 stick remaining.
5. Player has to take the final stick and loses.

Now, the situation with the AI is as follows:

Hat	1	2	3	4	5	6	7	8	9	10
Content	1,2,3	1,2,3	1,2,3	1,2	1,2,3	1,2,3	1,3	1,2,3	1,2,3	1,2,3
Beside				3			2			

As the AI wins the game, it will put the balls that are next to the hats back to the hats with extra balls. The situation is now as follows:

Hat	1	2	3	4	5	6	7	8	9	10
Content	1,2,3	1,2,3	1,2,3	1,2,3,3	1,2,3	1,2,3	1,2,2,3	1,2,3	1,2,3	1,2,3

Now the AI will more likely take 3 sticks in the case of four sticks remaining on the board, and 2 sticks in case there are 7 sticks remaining on the board.

Your task is to modify the human vs. human version of the game so that the player can choose to play against an AI that works as described above. After each game, the AI will update the contents of its hats. The AI will play relatively randomly at first, but you will notice that it will start to learn a strategy as you play against it.

The following example displays how the program should behave after you have finished this step.

```
Welcome to the game of sticks!
How many sticks are there on the table initially (10-100)? 10
Options:
 Play against a friend (1)
 Play against the computer (2)
Which option do you take (1-2)? 2

There are 10 sticks on the board.
Player 1: How many sticks do you take (1-3)? 3

There are 7 sticks on the board.
AI selects 2

There are 5 sticks on the board.
Player 1: How many sticks do you take (1-3)? 3
```

```
There are 2 sticks on the board.
AI selects 2
AI loses.
Play again (1 = yes, 0 = no)? 1

There are 10 sticks on the board.
Player 1: How many sticks do you take (1-3)? 1

There are 9 sticks on the board.
AI selects 1

There are 8 sticks on the board.
Player 1: How many sticks do you take (1-3)? 3

There are 5 sticks on the board.
AI selects 3

There are 2 sticks on the board.
Player 1: How many sticks do you take (1-3)? 2
You lose.
Play again (1 = yes, 0 = no)? 1

There are 10 sticks on the board.
Player 1: How many sticks do you take (1-3)? 3

There are 7 sticks on the board.
AI selects 2

There are 5 sticks on the board.
Player 1: How many sticks do you take (1-3)? 3

There are 2 sticks on the board.
AI selects 2
AI loses.
Play again (1 = yes, 0 = no)? 0
```

Part three: AI vs. AI

In the previous part we created an AI that is able to learn from playing against the player. As we play against it, we notice that it takes a considerable amount of time before the AI is able to perform against a human player. In this assignment, you need to modify the program so that the player can choose to play either against a naive AI or a pre-trained AI.

In order to pre-train an AI, you need to create a program that allows two AIs to battle against each others -- say a hundred thousand times (after the training is working, try out different numbers as well!) -- and after that the player will be set to play against the AI that is ready to battle the player.

The following example shows how the game would work with the trained AI option.

```
Welcome to the game of sticks!
How many sticks are there on the table initially (10-100)? 10
Options:
 Play against a friend (1)
 Play against the computer (2)
 Play against the trained computer (3)
Which option do you take (1-3)? 3
Training AI, please wait...

There are 10 sticks on the board.
Player 1: How many sticks do you take (1-3)? 3

There are 7 sticks on the board.
AI selects 2

There are 5 sticks on the board.
Player 1: How many sticks do you take (1-3)? 1

There are 4 sticks on the board.
AI selects 3

There is 1 stick on the board.
Player 1: How many sticks do you take (1-3)? 1
You lose.
Play again (1 = yes, 0 = no)? 1

There are 10 sticks on the board.
Player 1: How many sticks do you take (1-3)? 2

There are 8 sticks on the board.
AI selects 3

There are 5 sticks on the board.
Player 1: How many sticks do you take (1-3)? 2

There are 3 sticks on the board.
AI selects 2

There is 1 stick on the board.
Player 1: How many sticks do you take (1-3)? 1
You lose.
Play again (1 = yes, 0 = no)? 0
```

Once you have finished the program, it is time to challenge your friend with your awesome AI! ☺