In the Lemonade Stand Game, there are a total of 3 players and 12 places to set up their stall to sell lemonade over the course of 100 days. The price of lemonade is fixed for all players and the goal is to have the highest utility at the end of the game. I have implemented 5 different strategies for all players, 'equilibrium', 'random', 'popular spot', 'previous success', and collaboration which is divided into 2 strategies, 'collaborate1' and 'collaborate2'. Throughout the game, players will change strategies in an attempt to increase their utility.

The initial strategy I chose for all players is a cooperative strategy called 'equilibrium'. This is a cooperative strategy as when the players collude, they realise if they all choose the same location, it is an equilibrium, allowing them to all maximise their utility at the same time. This strategy is also a pure strategy because there is no randomness or probability involved when the players play their actions. However, there is an incentive for players to deviate from the equilibrium in order to increase their payoff by 4, from 8 to 12, by moving to a new location while the other 2 players remain at the same location, therefore, it is not a Nash equilibrium.

A Nash equilibrium would be if each player chooses a location that is equidistant from each other, for this game, it would be 4 spots away from each player. This would be a Nash equilibrium because each player won't have the incentive to deviate from their location as it would decrease their utility if they were to move away from their current location.

With the current 'equilibrium' strategy, if one player deviates from this strategy, the opposing players will then also deviate from their equilibrium strategy in response to the change. Resulting in a new set of strategies which can be seen after 10 days of the game played.

On the 11th day, player1 decides to deviate from the 'equilibrium' strategy to increase their utility. player1 updates their strategy to the 'random' strategy, picking any random location apart from 12 as this is the other players' location, this allows player1 to gain a higher utility compared to player2 and player3. I chose to implement a 'random' strategy as this strategy prevents the other players from predicting what location this player will play, effectively making it harder for the other players to exploit the player's predictable behaviour.

When day 11 starts, player2 and player3 realise that player1 has deviated from their agreed equilibrium location, therefore, on day 12, they both decide to update their strategies in order to try and maximise their own utility. If players2 and players3 were rational, they would switch to a collaboration strategy after the 11th day in order to maximise their utility, however, in my game they switch so that all players are now playing non-cooperative strategies.

Player2 decides to play the 'previous success' strategy, however, in order to gain a true view of which location has had the best success in previous days, player2 plays the 'random' strategy for 10 days and uses the data from those days to decide which location had the best utility overall. The locations are not recorded for the first 10 days as all players had the same location, hence, the same utility. Therefore, by using the days where each player has their own non-cooperative strategy, the utility will be more realistic assuming that player1 and player3 will not deviate from their new strategies**.** After playing the 'random' strategy for 10 days, player2 updates their strategy to 'previous success' where they will set their new location as the location which has had the most number of days with the highest utility. This strategy has been chosen as it looks at where has been the most popular spot amongst customers in hopes that it will maintain a high utility.

While player2 changes to the ‘previous success’ strategy, player3 updates their strategy to the ‘popular spot’ strategy. This strategy looks at all the previous locations and chooses the location that was the most popular amongst all the players. It was implemented as most players were selling lemonade in this location in the previous days, therefore, it should do well, incentivising the player to go back to set up their stand there. ‘popular spot’ strategy is not a pure strategy as player3 is taking all other players previous locations into account, meaning that the other player’s actions will ultimately affect player3’s decision.

If one of the players in the game has the highest utility for 5 consecutive days, the other 2 players will collaborate to maximise their utility while minimising the other players’ utility. This is a cooperative strategy as the 2 players have to discuss their locations with each other before the day starts. ‘collaborate1’ chooses a random location and ‘collaborate2’ chooses a location 6 spots away from that random location. For this strategy, I have chosen 6 spots as that is the maximum number of spots that allows the 2 players to maximise their utility.

If while the 2 players are collaborating, one of the players does consecutively well for 5 days, that player will stop collaborating with the other as they believe they are able to increase their payoff by themselves. The remaining 2 players will then collaborate together with the same strategy to try to maximise their utility.

There is no pure Nash equilibrium strategy in this game as pure Nash equilibrium is defined as ‘each player has chosen a pure strategy and no player can benefit by changing strategies while the other players keep theirs unchanged’. There is no dominant strategy in this game as players will constantly be looking for different ways to deviate from their current strategy assuming the others keep their strategies the same to increase their utility. Because of this, it makes it difficult to find a fixed outcome for the game.

My game uses mixed strategies, where each player chooses a strategy randomly with a certain probability. This is what my ‘random’, ‘popular spot’, and ‘previous success’ strategies are as each player has an equal chance of getting customers for the day.

After 100 iterations, my code prints out the outcomes, the total sum of profits for each player. The winner changes every time I run my code as many of my strategies are based on random numbers. An observation I made while playing this game is that cooperative strategies are the ones that tend to do better in the long run. For example, with the ‘collaborate1’ and ‘colllaborate2’ strategies, if player3 doesn’t do well in general, they will always be collaborating with another player, essentially allowing them to always maximise their utility. Therefore, cooperative strategies allow players to maximise their payoff the best.

If all the players were rational, they wouldn’t deviate from the initial ‘equilibrium’ strategy until towards the end of the game as it would increase their chances of winning. Additionally, if they started with all different non-cooperative strategies, by the end of the game-playing, it would lead to a pure Nash equilibrium (equidistant location) where they would all gain 8 as their utility as they would realise that this is the best possible solution for all players and have no incentive to move their lemonade stand. However, since my players are not rational, game-playing did not lead to equilibrium as all players wanted to maximise their utility. Therefore, the equilibrium strategies for this game depend on all the players' actions.