**STU22004 Applied Probability**

**Group Project**

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# Question 1

The aim of this question is to simulate 4 possible games or systems of betting on the roulette wheel and comparing the data under certain criteria from these simulations between each game.

Below is an analysis of the data received from simulating these games 10,000 times in excel.

## Game 1: Betting on Red

Seeing as there are a total of 37 slots on the roulette wheel, and 18 of them are coloured red, the probability of the ball landing on red is or 0.486 rounded to the 3 decimal places.

Using this information, we can use the RAND() function in excel to generate random values between 0 and 1, and by checking if these values are less than or equal to the calculated probability of the ball landing on red (0.486), we can determine whether the bet is lost or won. Using this, we can also determine which specific colour the ball landed on.

Using this method of simulation, we can repeat the bets 10,000 times and calculate the 5 criteria for the game.

Here are 5 simulations of the game to show as an example:

| **Reps** | **RAND()** | **Colour** | **Result** | **$ Won** | **Cumulative Winnings** |
| --- | --- | --- | --- | --- | --- |
| 1 | 0.138 | Red | Win | 1 | 1 |
| 2 | 0.776 | Black | Loss | -1 | 0 |
| 3 | 0.220 | Red | Win | 1 | 1 |
| 4 | 0.515 | Black | Loss | -1 | 0 |
| 5 | 0.854 | Black | Loss | -1 | -1 |

### C1. The expected winnings per game

By totalling the amount of games won over the 10,000 simulations we can calculate the expected winnings per game by using the following formula:

Where represents winning the bet.

Using this formula, we get a value for the expected winnings per game of 0.99$ (this is just for one simulation of 10,000 bets, this number can vary between simulations).

We are also asked to calculate the exact winnings per game for this game, which turns out to be 0.97$.

We can calculate the percentage error of these values by using the following formula:

Where represents the exact value and represents the estimated value.

Using this formula with the values calculated we get a percentage error of 2.05% rounded to 2 decimal places.

### C2. The proportion of games you win

The proportion of games won can be calculated simply by dividing the total amount of games won out of the 10,000 simulated games by the total amount of games played, which would be 10,000.

The resulting value for this simulation is 0.488 rounded to 3 decimal places. This value can change depending on the simulation results.

The exact value for this criteria is 0.486, which is also the probability of winning this game.

Using the same formula as above we get a percentage error for the proportion of games won of 0.393%.

### C3. The expected playing time per game

Since this game involves placing only one bet per game, the expected playing time per game for betting on red is 1 bet.

### C4. The maximum amount of money you can lose

Each game only takes the time of 1 bet, meaning that the maximum amount of money you can lose is the bet you placed, which is 1$. Over the 10,000 repetitions of the game, the maximum amount of money you can lose is 1,000$.

### C5. The maximum amount of money you can win

Each game only takes the time of 1 bet, meaning that the maximum amount of money you can win is 2$. Over the 10,000 repetitions of the game, the maximum amount of money you can win is 2,000$.

## Game 2: Betting on a Number

There are a total of 37 slots on the roulette wheel, and all of them are numbered, which means that if you are to bet on a specific number, the probability of you winning the bet would be or 0.027 rounded to 3 decimal places.

The simulation uses the RANDBETWEEN() function in excel to determine which number is being bet, and which number the ball lands on. Comparing these two numbers in each repetition, we can determine a win or loss.

Here is a table representing 5 repetitions of the game:

(The number chosen to bet on for these repetitions was 24)

| **Reps** | **Number** | **Result** | **$ Won** | **Cumulative Winnings** |
| --- | --- | --- | --- | --- |
| 1 | 28 | Loss | -1 | -1 |
| 2 | 5 | Loss | -1 | -2 |
| 3 | 18 | Loss | -1 | -3 |
| 4 | 19 | Loss | -1 | -4 |
| 5 | 35 | Loss | -1 | -5 |

### C1. The expected winnings per game

Much like the previous game, we can total the amount of games won from the simulation and use the formula to calculate the estimated expected winnings per game. This turns out to be 0.97$.

We can also calculate the exact expected winnings per game the same way as previously, which gives us a value of 0.95$.

The percentage error of the expected winnings per game between the estimated and exact values is 2.11% rounded to 2 decimal places.

### C2. The proportion of games won

The estimated proportion of games won for this simulation is 0.028, while the exact proportion is 0.027.

This means the percentage error for this criteria is 3.70% rounded to 2 decimal places.

### C3. The expected playing time per game

Since this game involves placing only one bet per game, the expected playing time per game for betting on a number is 1 bet.

### C4. The maximum amount of money you can lose

Each game only takes the time of 1 bet, meaning that the maximum amount of money you can lose is the bet you placed, which is 1$. Over the 10,000 repetitions of the game, the maximum amount of money you can lose is 1,000$.

### C5. The maximum amount of money you can win

Each game only takes the time of 1 bet, meaning that the maximum amount of money you can win is 35$. Over the 10,000 repetitions of the game, the maximum amount of money you can win is 35,000$.

# Question 2