1. Every bet we win, our earning increase by 1$. So to get 80$, we need at least 80 wins out of 1000. (Only the first 80 matter, because after that we can basically have anything as we're terminating the algorithm). Mathematically, if p is the probability of winning, the value comes out to be

   $$1000C80p^{80}(1-p)^{920} + ... + 1000C1000p^{1000}(1-p)^{0}$$, p = 0.473

   When calculated empirically, the answer is 1 as all the experiments reach the value of 80 at the end.

2. All the 1000 experiments reached the value of 80$ at the end. So estimated expected value is 80.

3. Yes, Standard deviation initially oscillates and then reaches 0.Initially the sd oscillates a lot as different experiments might have different values of win,lose sequences, resulting in varied set of estimated_earnings. However, towards the end, all the experiments culminate in the value of 80%, so sd becomes 0. (And when a graph start from 0, increases and again reaches 0 towards the end, there must be a maximum somewhere in between)

4. Here, only 639 simulations out of 1000 reached the estimated_earnings of 80$. So the probability of getting 80$ at the end is 0.639

   Theoretical analysis is a bit more involved though. We need to get 80 wins and before that we have at max 8 consecutive losses.

5. 639 games result in the earning of 80$ and the rest 361 result in the earnings of -256$. So the expected value is (639*80 - 361*256)/1000 = **-41.2$**

6. No. Standard deviation keeps on increasing and then flattens at the maximum value. This is because our losses are bounded by 256 and gains are bounded by 80. And that's the maximum possible values throughout the experiment and they're reached towards the end.
7. (Figures in next page)

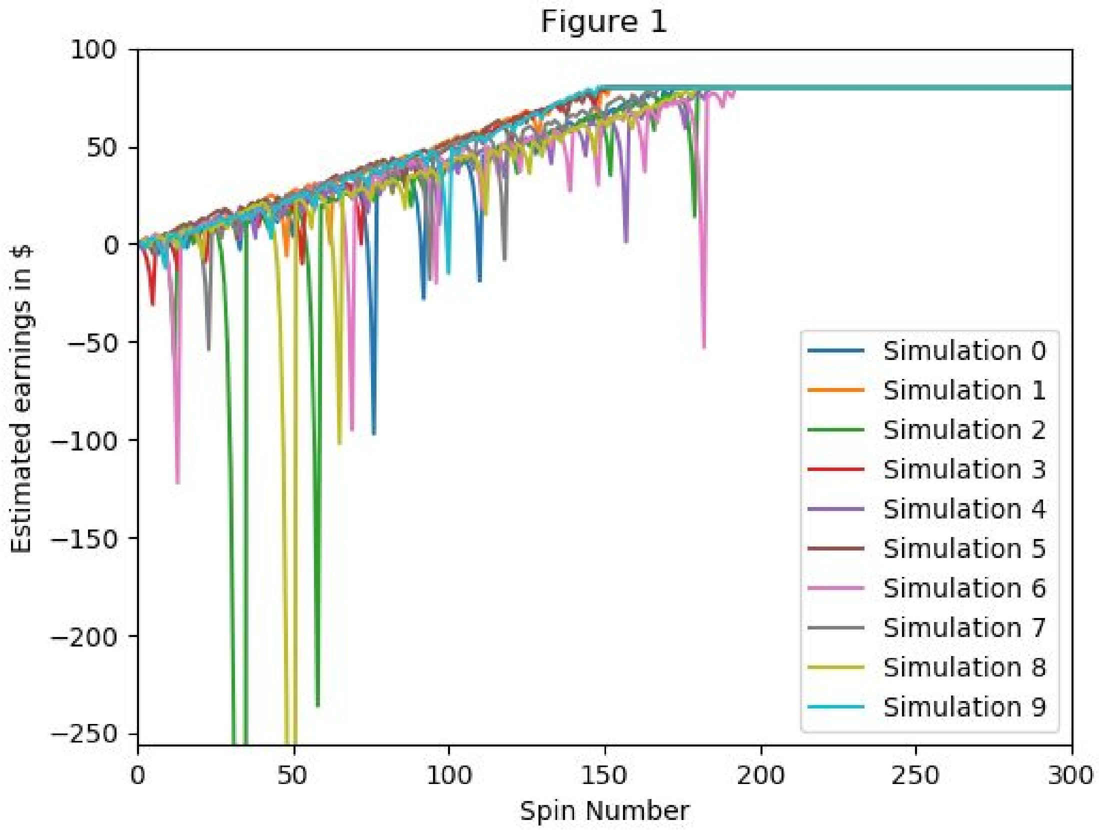
Figure 1
Estimated earnings in $
Spin Number
100
50
0
−50
−100
−150
−200
−250
0
50
100
150
200
250
300
Simulation 0
Simulation 1
Simulation 2
Simulation 3
Simulation 4
Simulation 5
Simulation 6
Simulation 7
Simulation 8
Simulation 9

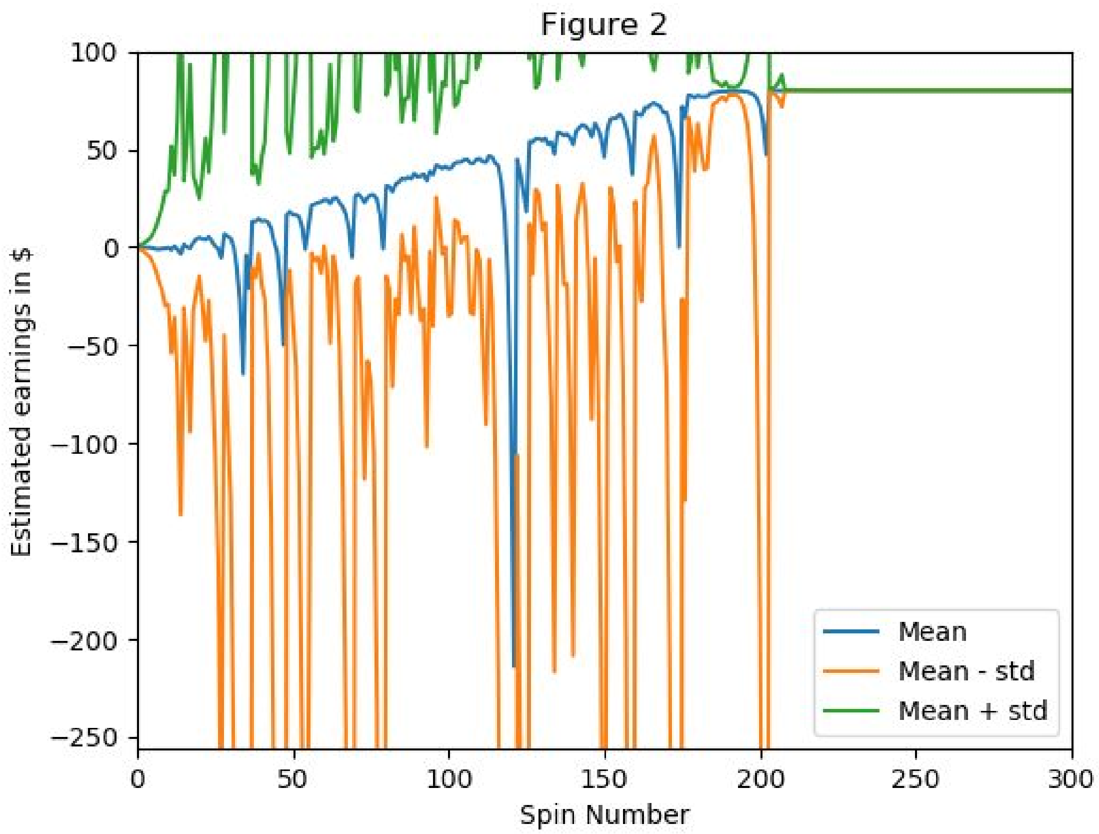
Figure 2
Estimated earnings in $
Spin Number
100
50
0
−50
−100
−150
−200
−250
0
50
100
150
200
250
300
Mean
Mean - std
Mean + std

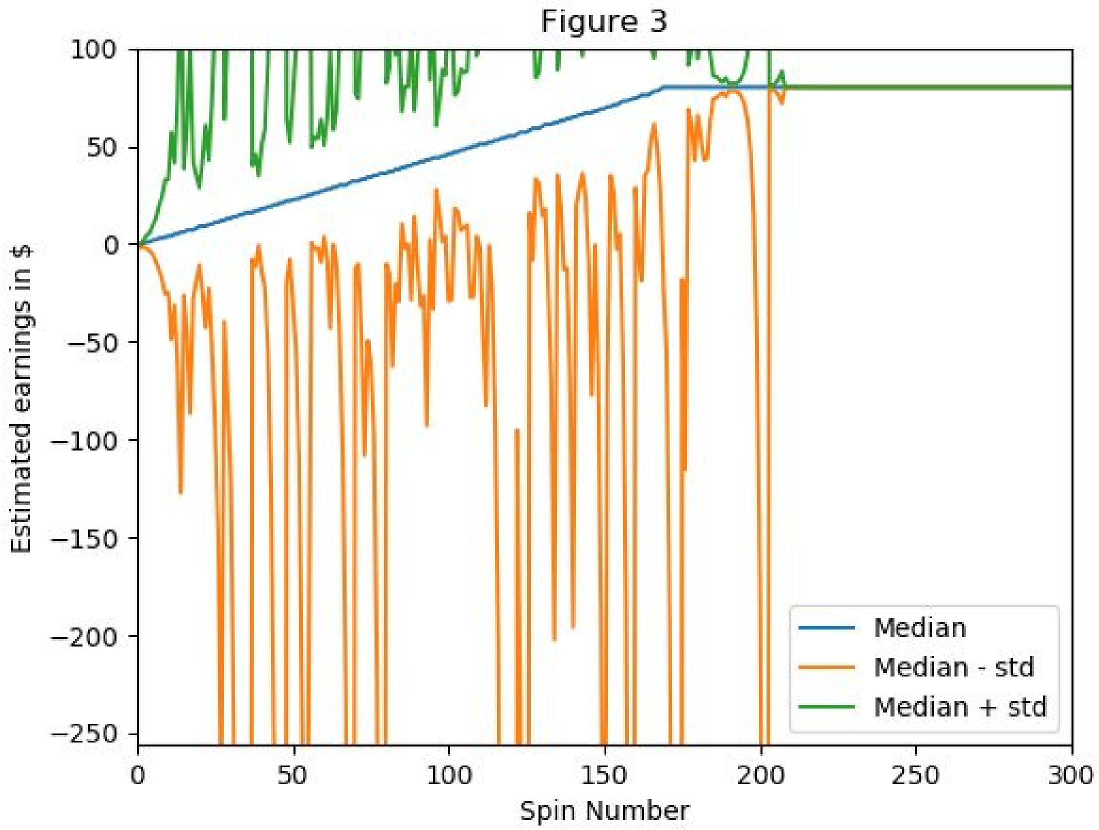
Figure 3
Estimated earnings in $
Spin Number
100
50
0
−50
−100
−150
−200
−250
0
50
100
150
200
250
300
Median
Median - std
Median + std

Figure 4

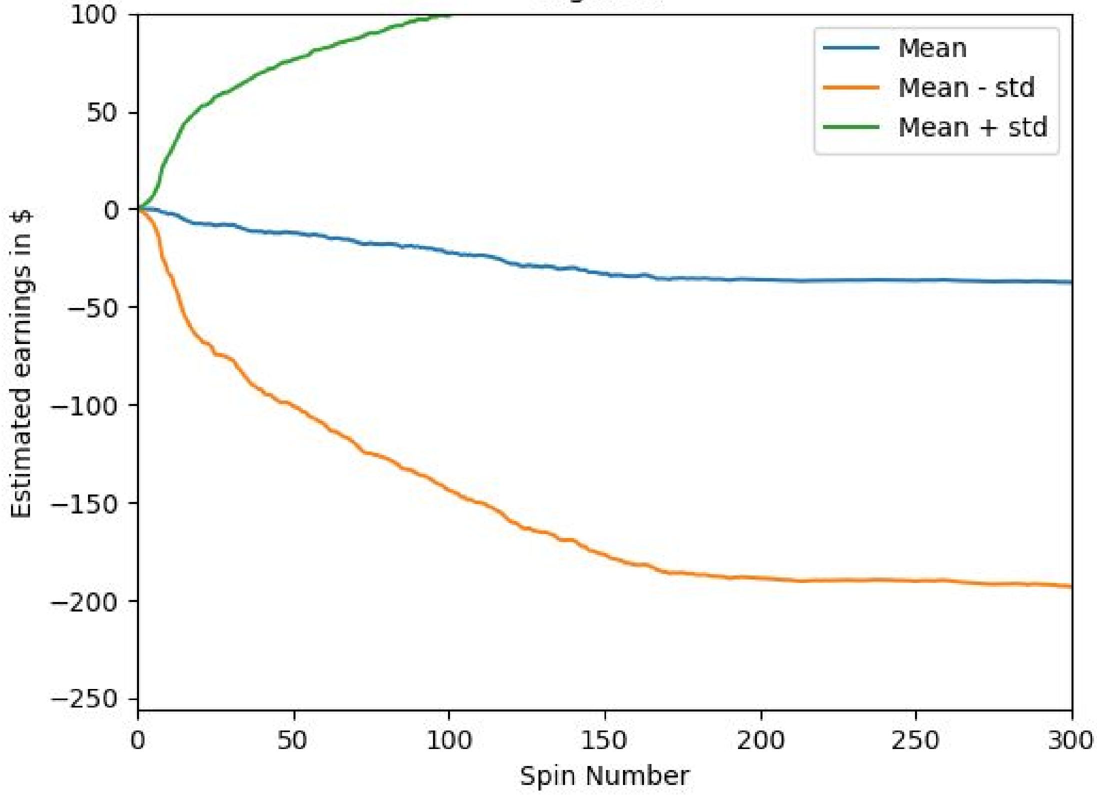

Figure 5