

Powerball

Recently the Powerball drawing had a 320 million dollar winner. I wonder what the odds are of winning that and whether the prize money is equivalent to how much the Lottery takes in for that game. Bet not.

How does Powerball work?

Powerball® is a lottery game played in 44 states plus Washington DC. Every Wednesday and Saturday night at 10:59 p.m. Eastern Time, they draw five white balls out of a drum with 59 balls and one red ball out of a drum with 35 red balls. You can enter up to one hour before the draw.



The last jackpot was huge ... 320 million dollars.

How do you figure whether this game is worth spending your \$2 for a ticket?

Five white balls will be chosen from the drum and the order of the drawing doesn't matter.

1. If I chose 5 numbers and paid my \$2 entry fee, what would be the chance of one of my numbers being chosen on the first draw?

To calculate my chances of getting one of my numbers chosen on the first draw, I guess that I have 5 chances of success and 59 balls that could be chosen. Probability is the number of ways that success could happen, divided by the number of ways of choosing any ball. So, you hopefully had $\frac{5}{59}$ as your answer to problem # 1.

The tricky part comes when you try to figure out what your chances of having two of your numbers chosen. Let's try this with a smaller number of choices.

Suppose there are only 4 balls in the drum and I chose the numbers #1 and #2 to win.



- On my first draw I was successful and, luckily, one of my winning numbers was chosen. I would have had two chances of winning out of the 4 balls in the drum = probability of $\frac{2}{4}$.
- For the second draw the probability would be different. There is now only one winning choice left and there are only 3 balls still in the drum. I only have one possibility for success out of the 3 balls that are in the drum. My probability of success for that 2nd draw is now $\frac{1}{3}$.

But what do I do with $\frac{2}{4}$ and $\frac{1}{3}$ to figure out the probability of getting both of my choices in the two draws?

To help figure this out, I've made a chart with all of the ways that the two balls could have been chosen.

1	2	2	1	3	1	4	1
1	3	2	3	3	2	4	2
1	4	2	4	3	4	4	3

There were 12 ways that the numbers could have been drawn from the drum and only 2 of them would have made me a winner. So $\frac{2}{12}$ is my probability of choosing the two correct winning numbers.

2. What operation could you have used to combine $\frac{2}{4}$ and $\frac{1}{3}$ to get $\frac{2}{12}$? Does that make any sense to you?

Back to the real Powerball game

3. If I chose 5 numbers from the 59 numbers that are in the drum, what is the probability of the first number drawn being one of my choices?
4. If that first number drawn was one of my winners, how many balls are left in the drum and how many balls are left that would be one of my choices? What is the probability of my having a successful second ball drawn?
5. If I got the 2nd number also and a third number was drawn, what is my probability of getting that 3rd number as one of mine?
6. How about the 4th number drawn if I was successful on the first 3.
7. And the 5th?

To find the total probability of this event being successful, that is, my winning all 5 numbers, I would need to multiply all of the individual draw probabilities together. (I think that for each successive draw it would be harder and harder to expect to draw one of my choices. That's one reason why you multiply the individual probabilities. Each less than 1 probability times another less than one probability will create an even smaller probability.)

8. What would the final probability of my getting all 5 of my numbers drawn?

There is a formula for choosing r items from n possibilities where order doesn't matter.

${}_n C_r = \frac{n!}{r!(n-r)!}$ where "r" = number of items to be chosen and "n" = total number of items that are possible to choose.

Since the lottery probability is $\frac{\text{number of ways of drawing one of my winning numbers}}{\text{number of ways of drawing any number}}$, I could calculate probability by doing this math;

$$\frac{{}_5 C_5}{{}_{59} C_5} = \left(\frac{5!}{5! \cdot 0!} \right) / \left(\frac{59!}{5! \cdot 54!} \right) = \left(\frac{120}{120 \cdot 1} \right) / \left(\frac{59 \cdot 58 \cdot 57 \cdot 56 \cdot 55 \cdot 54!}{120 \cdot 54!} \right) = \frac{1}{5,006,386}$$

Powerball Jackpot

In order to win the jackpot prize, you would need to get all 5 white predictions correct and the red ball correct.

9. How many red balls are in the red ball drum?

10. What is the probability of drawing the correct red ball?

I found this chart on the Powerball website. Let's see if we get the same calculations. Let's do the math.

Match	Prize	Odds
	Jackpot	1 in 175,223,510.00
	\$1,000,000	1 in 5,153,632.65
	\$10,000	1 in 648,975.96
	\$100	1 in 19,087.53
	\$100	1 in 12,244.83
	\$7	1 in 360.14
	\$7	1 in 706.43
	\$4	1 in 110.81
	\$4	1 in 55.41

The overall odds of winning a prize are 1 in 31.85.
The odds presented here are based on a \$2 play (rounded to two decimal places).

11. Show the math of getting 5 white balls and 1 red ball correct.

Powerball Simulator

I want to see if this math really works. I found a simulator to use for Powerball at <http://justwebware.com/powerball/powerball.html>. Well, to test this I am certainly not going to repeat the game 175 million times to see if I win the jackpot.

12. Using the previous chart, how many times might I have to repeat the simulator game to get the red Powerball alone to turn up?

13. Try the simulator game and keep a record with tallies of your attempts and wins.

- You can set the simulator to STOP whenever any of the matches win in the boxes on the left.
- You can choose your own numbers by unchecking the Quick Pick box.
- Check the Show Matches box.
- When you have chosen your numbers and are ready to begin, press Start.

Attempts	Win of any kind	Power ball correct

14. How many times did the simulator replay before you got the Powerball number correct?

15. Was that number identical to the mathematical probability calculation?

16. Why do you think these two probabilities are the same or different?

There is another lottery game called Mega Millions. Mega Millions drawings are held Tuesday and Friday evenings at 11:00 p.m. Five balls are drawn from a set of balls numbered 1 through 56 and one gold ball is drawn from a set of balls numbered 1 through 46. You win if the numbers on your ticket match the numbers of the balls drawn on that date. Your mega ball number can be a repeat of any of the first five numbers but cannot be used as one of the first five numbers in order to win.



17. Which lottery, Mega Millions or Powerball, gives you a better chance of winning the grand prize? Show how you determined which lottery gives you a better chance.

Source: http://www.powerball.com/powerball/pb_howtoplay.asp
<http://justwebware.com/powerball/powerball.html>
<http://www.megamillions.com/>