



Solving probability problems using simulation

Year 11
Mathematical Methods

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Learning Objectives

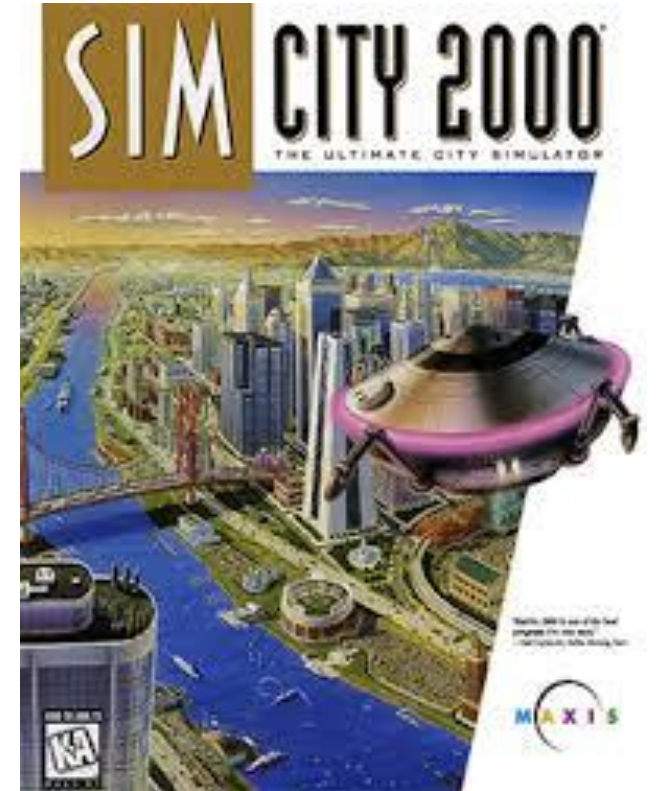
By the end of the lesson, I hope that you understand and can apply the following to a range of questions from the Year 11 Mathematical Methods course.

- Understand what simulation is
- Understand how we can apply real world objects to help us simulate simple and complex problems
- Know how to use the CAS to find a set of random numbers.



RECAP

We have spend a lot of time looking at the probability work which has, in fairness, been covered in previous years. Now we move onto something much more exciting! Simulation.



A family of 6 with at least four girls?!

In Ireland, quite a few years ago, it wasn't uncommon for families to have large numbers of children. We won't go into the reasons why ... as that would be better covered in HPE.

My Dad is one of 13 children. Yup. He is a member of a good Catholic family.

I wonder if my grandmother was trying for a football team? Or a certain number of girls?

As it happens, she could have used something as simple as a die to help her find the probability of having, for example, at least 4 girls.

To make it easier, let's assume she wanted a family of only 6.



Simulation using a Die: Trial 1

Let's throw a die 6 times. Each time it comes up Heads we will say we had a girl. It's obvious what a Tail will now stand for.

Some assumptions need to be made:

- There is an equally likely chance of a boy or girl being born
- The probability of having a girl, followed by a girl is independent.

T	H	H	T	T	H	3
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This is one trial. We know that, in this case, there were 3 girls born. But we might need to do more than one trial. How many though?



Simulation using a Die: Trial 2

Let's throw a die 6 times. Each time it comes up Heads we will say we had a girl. It's obvious what a Tail will now stand for.

Some assumptions need to be made:

- There is an equally likely chance of a boy or girl being born
- The probability of having a girl, followed by a girl is independent.

T	H	H	T	T	H	3
H	H	H	T	H	T	4



Simulation using a Die: Trial 3

Let's throw a die 6 times. Each time it comes up Heads we will say we had a girl. It's obvious what a Tail will now stand for.

Some assumptions need to be made:

- There is an equally likely chance of a boy or girl being born
- The probability of having a girl, followed by a girl is independent.

T	H	H	T	T	H	3
H	H	H	T	H	T	4
H	H	H	T	H	H	5

Now ... we could continue doing this, but this video would be VERY, VERY, VERY long as we would probably want to do 50 or 100 trials or more!



Simulation using a Die: 50 Trials

Let's see what happens when we do 50 trials.

With the information in the table we can now have a better idea at answering the question, "What is the probability that in a family with 6 children, 4 or more will be girls?"

Heads	0	1	2	3	4	5	6
Number of times obtained	1	5	12	15	13	3	1

$$\Pr(4 \text{ or more}) = \frac{17}{50} = \underline{\underline{0.34}}$$



Example 2

A pizza shop is giving away football cards with each pizza bought. There are six different cards available, and a fan decides to continue buying the pizzas until all six are obtained. How many pizzas will need to be bought, on average, to obtain the complete set of cards?

How would we use simulation with the example above?



Example 2: Assumptions

A pizza shop is giving away football cards with each pizza bought. There are six different cards available, and a fan decides to continue buying the pizzas until all six are obtained. How many pizzas will need to be bought, on average, to obtain the complete set of cards?

Let's make some assumptions:

- The six cards will all occur with the same frequency (unlike playing Monopoly on my phone)
- The card obtained with one pizza is independent of the cards obtained with other pizzas



Example 2: Using a die (⁶6-sided)

A pizza shop is giving away football cards with each pizza bought. There are six different cards available, and a fan decides to continue buying the pizzas until all six are obtained. How many pizzas will need to be bought, on average, to obtain the complete set of cards?

Let's throw an ⁶6-sided die. And keep throwing it until we collect all 6 cards (that is all 6 numbers have appeared at least once).



Example 2: Trial 1

A pizza shop is giving away football cards with each pizza bought. There are six different cards available, and a fan decides to continue buying the pizzas until all six are obtained. How many pizzas will need to be bought, on average, to obtain the complete set of cards?

Let's throw an ⁶8-sided die. And keep throwing it until we collect all 6 cards (that is all 6 numbers have appeared at least once).



5 2 5 2 2 2 3 3 1 2 6 3 5 4

14 pizzas needed to be purchased.
But this was only one trial.
Guess what we need to do now ...



Example 2: 50 Trials

A pizza shop is giving away football cards with each pizza bought. There are six different cards available, and a fan decides to continue buying the pizzas until all six are obtained. How many pizzas will need to be bought, on average, to obtain the complete set of cards?



These are the results of how many pizzas need to be bought with 50 trials!

14	8	12	11	16	8	8	11	15	26
14	20	11	13	35	23	19	14	10	10
20	9	10	14	29	13	7	15	15	22
9	10	14	16	14	17	12	10	24	13
19	27	31	11	9	16	21	22	8	9



Example 2: Finding the average

A pizza shop is giving away football cards with each pizza bought. There are six different cards available, and a fan decides to continue buying the pizzas until all six are obtained. How many pizzas will need to be bought, on average, to obtain the complete set of cards?

Adding all these numbers together and dividing by 50 will give me an estimate of the number of pizzas I would need to buy to collect all the cards.

14	8	12	11	16	8	8	11	15	26
14	20	11	13	35	23	19	14	10	10
20	9	10	14	29	13	7	15	15	22
9	10	14	16	14	17	12	10	24	13
19	27	31	11	9	16	21	22	8	9

Approximately **15 pizzas**



Using a CAS to generate random numbers

This is a CAS enabled course and so it makes sense to be able to use the CAS to find random numbers. This might come in handy as the course progresses!



Learning Objectives: Reviewed

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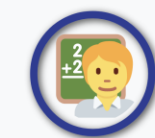
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