Birthday Paradox

Explained by Lydia :)

Initial Guess!

What do you think the chance is that two people in this class share a birthday?

If you already know the right answer - shhhh!

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What do you think the chance is that two people in this class share a birthday?

How many people do you think you need in a room for a 50% chance that there is a shared birthday?

If you already know the right answer - shhhh!

Probability

Probability: likelihood an event happens

$$P(\text{event}) = \frac{\text{ways that work}}{\text{all possible ways}}$$

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Q1: What is the probability of drawing a King out of a standard deck of cards?

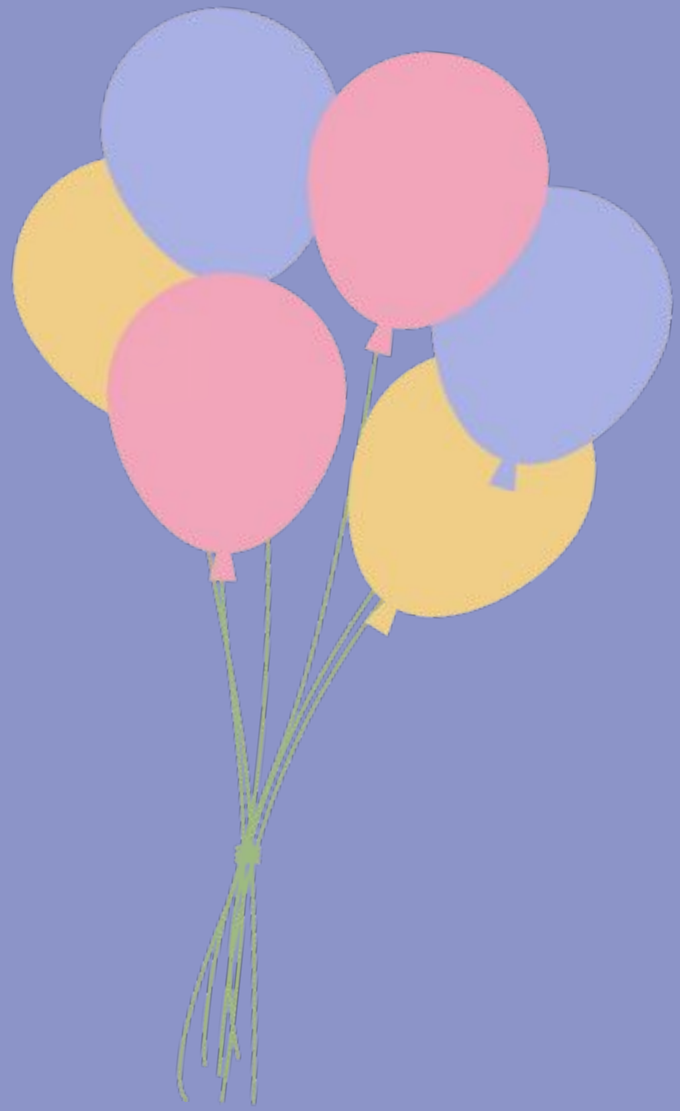
Q2: What is the probability of drawing a heart out of a standard deck of cards?

Complements

Complement: the *opposite* of an event...

One of them *has* to happen!

P(event) = 1 - P(not event)



Complements

Complement: the *opposite* of an event...

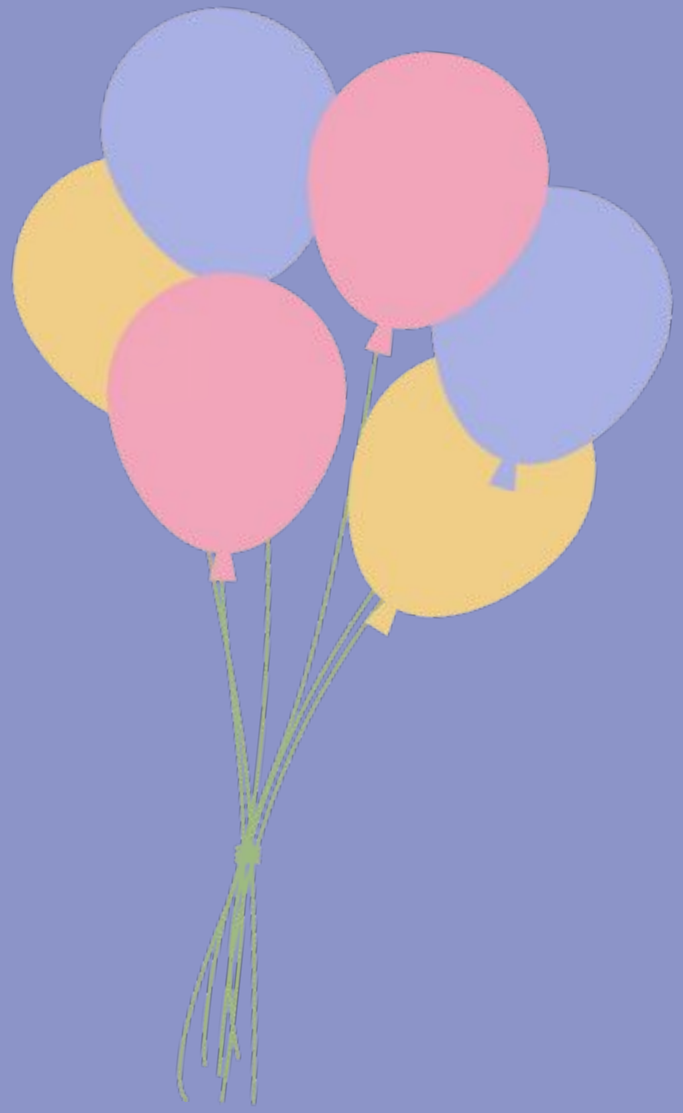
One of them *has* to happen!

P(event) = 1 - P(not event)

Q1: What is the complement to it being rainy?

Q2: What is the complement to drawing a King?

Q3: What is the complement to even numbers?



Why Complements?

Sometimes, it is easier to find the chance that something doesn't happen.

- It's *hard* to directly compute the chance at least two people share a birthday.
- It's *easier* to find the chance no one shares a birthday, then subtract from 1.

Computing No Shared Birthdays

1 Person: What's the likelihood that in a group of 1 person, there will be no shared birthdays?

Computing No Shared Birthdays

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$$\frac{365}{365} = 1 = 100\%$$

person 1

Computing No Shared Birthdays

1 Person: What's the likelihood that in a group of 1 person, there will be no shared birthdays? 100%

2 People: What's the likelihood that in a group of 2 people, there will be no shared birthdays?

Computing No Shared Birthdays

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$$\underbrace{\frac{365}{365}}_{\text{person 1}} \times \underbrace{\frac{364}{365}}_{\text{person 2}} = \frac{365 \times 364}{365^2} = 0.99726 \approx 99.7\%$$

Computing No Shared Birthdays

1 Person: 100%

2 People: 99.7%

3 People: What’s the likelihood that in a group of 3 people, there will be no shared birthdays?

Computing No Shared Birthdays

1 Person: 100%

2 People: 99.7%

3 People: What's the likelihood that in a group of 3 people, there will be no shared birthdays?

$$\underbrace{\frac{365}{365}}_{\text{person 1}} \times \underbrace{\frac{364}{365}}_{\text{person 2}} \times \underbrace{\frac{363}{365}}_{\text{person 3}} = \frac{365 \times 364 \times 363}{365^3} = 0.99179 \approx 99.2\%$$

Computing No Shared Birthdays

1 Person: 100%

2 People: 99.7%

3 People: 99.2%

10 People: What’s the likelihood that in a group of 10 people, there will be no shared birthdays?

Computing No Shared Birthdays

1 Person: 100%

2 People: 99.7%

3 People: 99.2%

10 People: What's the likelihood that in a group of 10 people, there will be no shared birthdays?

$$\underbrace{\frac{365}{365}}_{\text{person 1}} \times \frac{\ldots}{\ldots} \times \underbrace{\frac{356}{365}}_{\text{person 10}} = \frac{365 \times \ldots \times 363}{365^{10}} = 0.88305 \approx 88.3\%$$

Computing No Shared Birthdays

1 Person: 100%

2 People: 99.7%

3 People: 99.2%

10 People: 88.3%

General Formula:

$$\frac{365 \times \ldots \times (365 - n + 1)}{365^n}$$

Continuing the Trend...

# People	P(not sharing)	P(sharing)
1	100.0%	0%
2	99.7%	0.3%
3	99.2%	0.8%
4	98.4%	1.6%
5	97.3%	2.7%
6	96.0%	4.0%
7	94.4%	5.6%
8	92.6%	7.4%
9	90.5%	9.5%
10	88.3%	11.7%

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50	3.0%	97.0%
75	0.03%	99.97%

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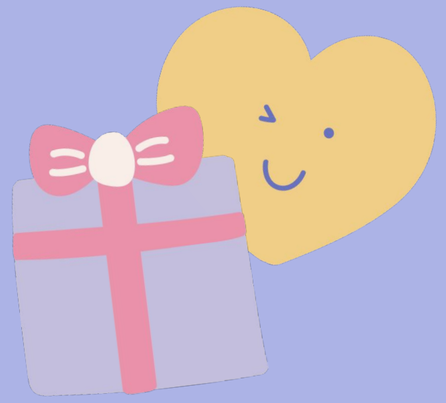
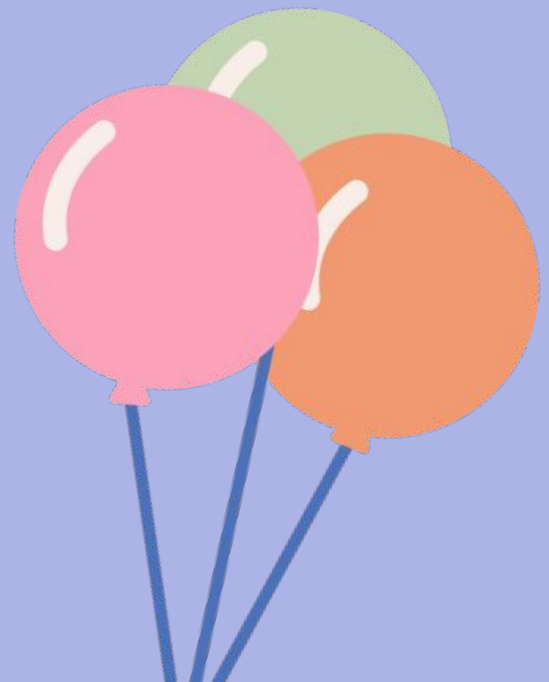
50	3.0%	97.0%
75	0.03%	99.97%
100	0.00003%	99.99997%
366	0%	100%

Takeaways

- **Probability:** likelihood of an outcome
- **Complement:** something ***not*** happening
- With **23 people**, there's a 50%+ chance of a shared birthday!





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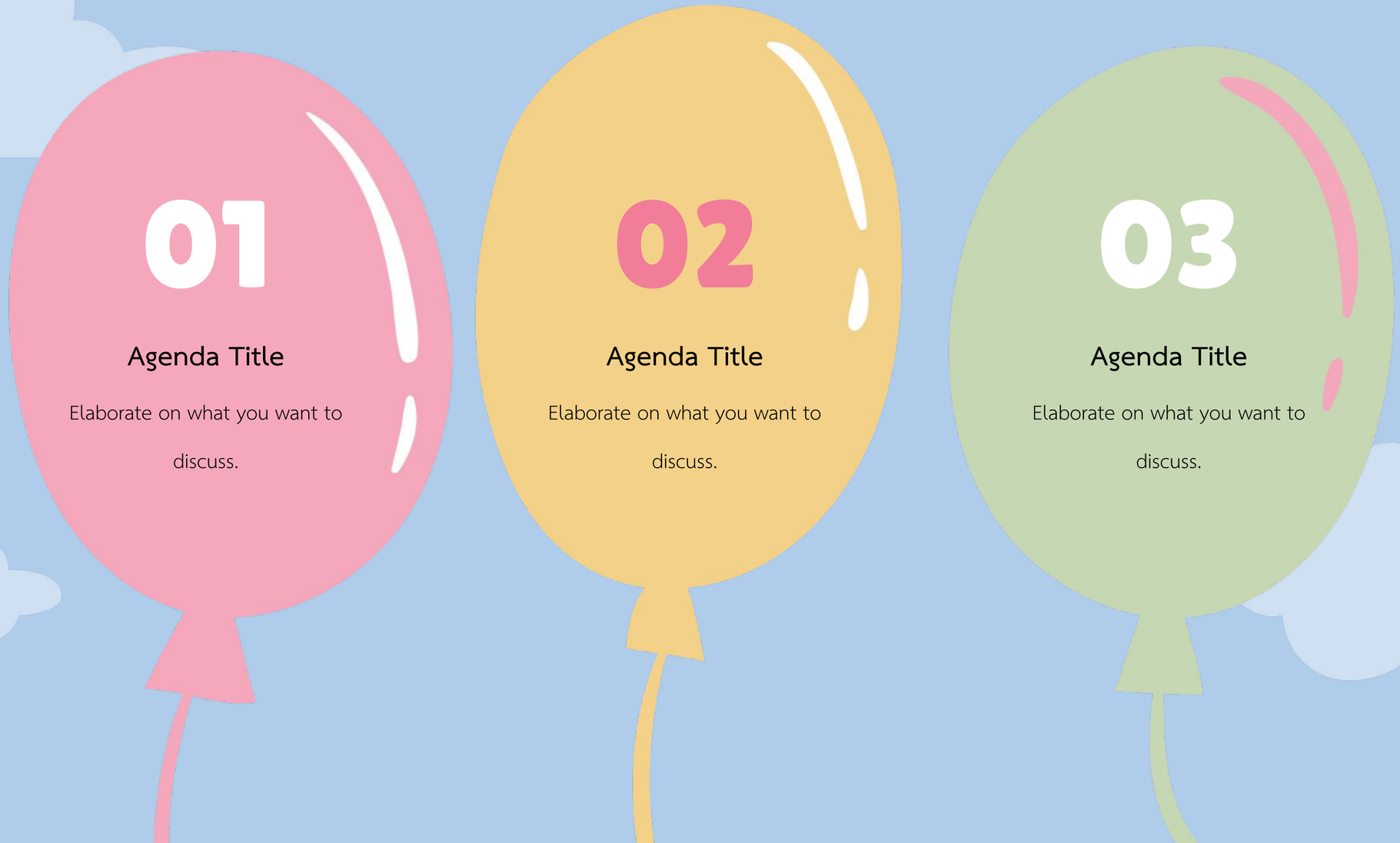

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