Webinar #1: Think like a Physicist

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Part I: Probability and Assumptions.

"The first principle is that you must not fool yourself and you are the easiest person to fool" – Richard P. Feynman

When it comes to probability questions, it turns out that most people's **intuition** will lead them to the **wrong** answer, and it takes considerable training to bypass your brain's auto-pilot, particularly when dealing with conditional probability.

You should be well-practiced with drawing tree and Venn diagrams to tackle straight-forwards probability questions[1].

Note: You should **not** need a calculator for ANY of these problems.

1. **Die Rolls**

   Which is the most likely sequence of die rolls?

   (a) 1 3 6 2 6 3 1 6

   (b) 1 3 6 5 2 6 3 1 4

   (c) 1 6 1 6 1 6 1

2. **π versus e**

   What is the probability of finding the consecutive sequence of digits …123456789…. in:

   a) $\pi \approx 3.14159265358979323846264338327950288419716939937510582097494 \ldots$

   b) $e \approx 2.71828182845904523536028747135266249775724709369995957496696 \ldots$

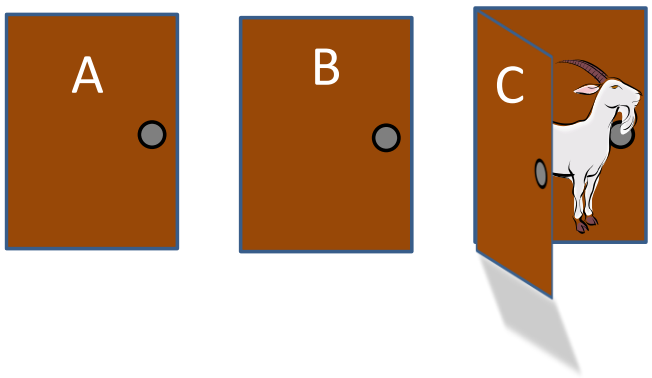
3. **Monty Hall**

   This problem split the academic community down the middle[2].

[1] If you want to practice some probability, try out these 2 boards on Isaac Science: https://isaacscience.org/question_decks#maths_book_gcse_ch9_52_higher , https://isaacscience.org/question_decks#maths_book_gcse_ch9_53_higher

[2] Its Wikipedia page has 69 references! https://en.wikipedia.org/wiki/Monty_Hall_problem

Here's the set-up: In the prize round of a gameshow, you are presented with the choice of selecting one of three identical doors. Behind one of the doors is a car, behind the other two are goats – you really don't want a goat.



You selected door B at random – you had a 1 in 3 chance of being correct.

The gameshow host (who knows the location of the car), says "it's a good job you didn't pick door C" as he opens it to reveal a goat. All of a sudden your odds have improved to 1 in 2 – fantastic!

You know what's coming next, it happens every week – your final decision…

Will you stick with your original selection, or are you better off by switching to A? What does your gut tell you?

4. Three daughters?

Imagine I have 3 children, and I pull out a photo from my wallet to show you a picture of one of my children at random, who just so happens to be a girl.

a) Given this, and only this information, what is the probability that I have 3 daughters?

b) Would the probability change if I were to tell you that she was my eldest, youngest or favourite child?

c) What if she was holding a trophy in the picture, and we could infer that of my 3 children, she was the most sporty?

5. Black and White

Three cards are shuffled and laid out under a cloth. You know that one card is white on both sides, one is black on both sides and the other is black on one side and white on the other.

A card is randomly pulled from under the cloth – it's white.

Given this, what's the probability that its other side is also white?

6. False-positive

1 in 100,000 people have a certain disease. The test for this is 99.9% accurate.

Bobbie administered the test and reports that it has comes back positive.

What are the odds that you actually have the disease?

Can you always trust expectation values though? Consider playing the following game…

7. Two Envelopes Paradox?

Envelopes, labelled A and B, contain cheques for a certain amount of money. You know for certain that one is double the value of the other.

a) Let's say you pick A, you open it up and the cheque is for £250. You're now given the option to stick or twist – what should you do?

b) Now play another round with envelopes C and D. This time you pick envelope D. The cheque says it's for an amount x, will you stick or twist now?

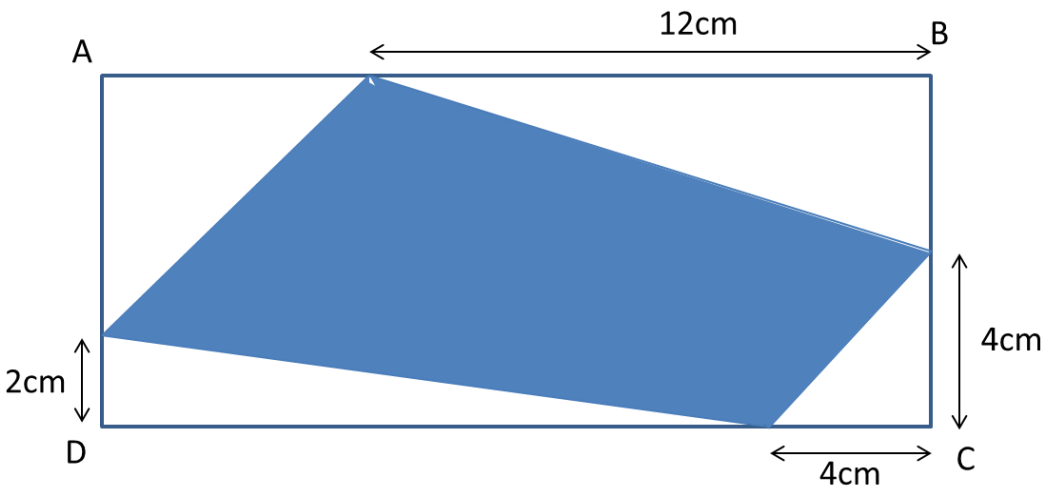
c) Final time, Envelopes E and F – take your pick. But before you even open it, aren't you just going to choose the other one anyway? Why not just pick that one at the start then?

Part II: Building a problem solving toolbelt

The relationship between the next set of problems is that they can all be solved in under 2 minutes. They may initially look hard, but are surprisingly simple, if you can find the right approach!

8. Rectangle

Rectangle ABCD below has an area of 120cm^2.



Find the area of the shaded part.

9. Ant

An ant is at one corner of a sugar cube of side length a.

How far must it travel, along the surface of the cube, to reach the far corner of the cube?

10. Squash vs water

You pour 100 ml of squash into one glass and 100 ml of water into another. You then takes a 30 ml shot glass and scoop 30ml of squash into the water

and give it a good mix. You then take the shot glass and transfer 30 ml of the mix back into the squash glass.

Is there more water in the squash glass or squash in the water glass?

11. Two Painters

Aled and Morgan offer to paint the outside of my house.

Aled says he'll complete the job in 3 days, whereas Morgan claims they can do the job in only 2 days.

I'm in a rush so I hire them both to work together, one going clockwise and the other anticlockwise around the house.

How long should it take to complete the job together?

12. Three Painters

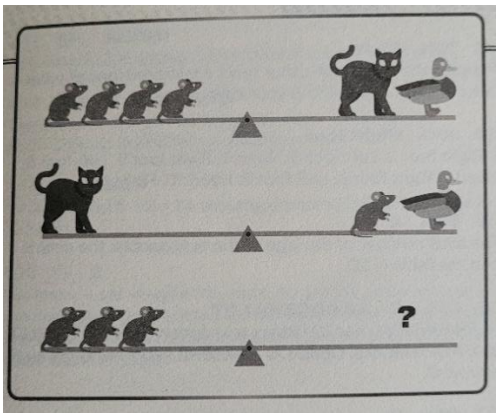
Kam and Chris spend 4 hours painting a fence together, then Femi helps out and the job is finished in 2 more hours.

Had Femi not helped it would have taken Kam and Chris 5 more hours to finish working together.

How long would it take Femi to have painted the fence on her own?

13. Rats

How many ducks would be needed
to balance 3 rats?



14. Punting

Sam punts 2 miles down the river Cam from Silver Street to Granchester Meadows in 5 hours.

After re-energising with some tea and scones, they punt at the same rate during the return journey, but this only takes 3 hours.

How fast is the current?