

13<sup>th</sup> Feb. 2023

# Probability & Statistics



## Class #1

Welcome to  Maths Module !

let's start @ 9:05

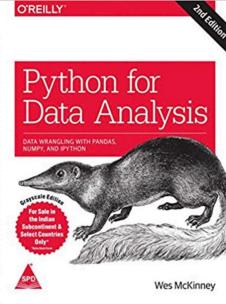
# Industrial Example of Probability

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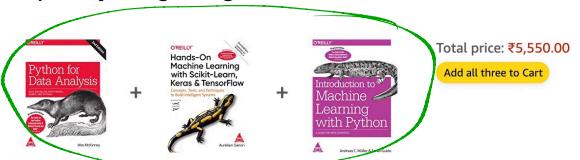
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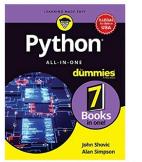
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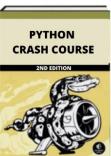
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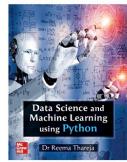
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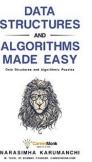
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Original



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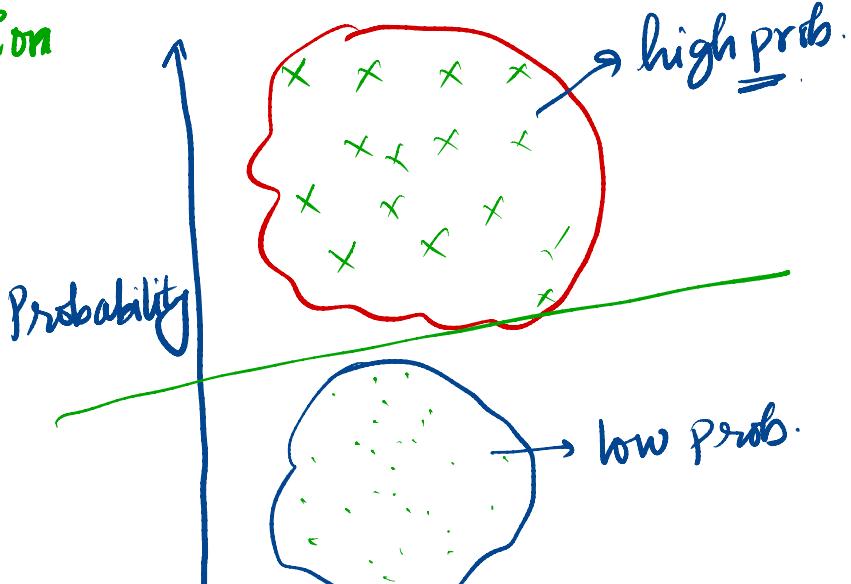
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me)



# financial domain - Probability

Bank  $\rightarrow$  10 million

1000 calls



100 responded

$\approx 0.01\%$

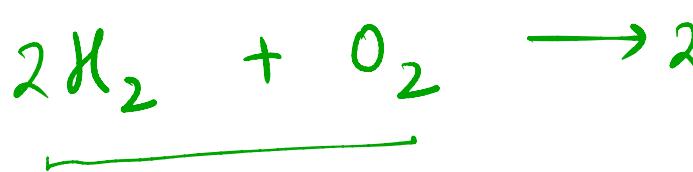
10K calls  $\rightarrow$  100  $\rightarrow$

1/1

90K calls

## Basic Terminologies :

Experiment → ?



water

100%.

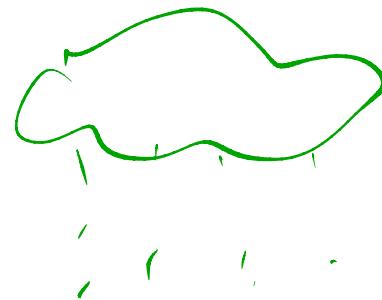
Prob. = 1.0

deterministic Expt.

$$1+2 = 3$$

## Random Experiments : ( outcome is unknown ).

- Coin toss ( H / T )
- Die ( 1 to 2 )
- Rain ( Y / N )
- Child Birth ( B / G )
- Rainfall ( in mm )



## Experiments - Random

### Outcome:

Toss a coin :  $\{H\} \cup \{T\}$

die :  $\{1\}, \{2\}, \{3\}, \{4\}, \{5\}, \{6\}$

Sample Space :  $\rightarrow$  {collection of all possible outcomes}

Coin :  $\{H, T\}$

die :  $\{1, 2, 3, 4, 5, 6\}$

Event: SS of die = {1, 2, 3, 4, 5, 6}

E<sub>1</sub>: getting all odd #'s = {1, 3, 5}

E<sub>2</sub>: — even #'s = {2, 4, 6}

E<sub>3</sub>: getting perfect square = {1, 4}

Event is  
Subset of  
Sample  
Space.

E<sub>4</sub>: {1, 4, 7} not an event  
not apart of SS impossible event.

## Sample Spaces

Akash  $\rightarrow A$   
Vaibhav  $\rightarrow V$

$A \rightarrow$  Die or  $D_1$        $V \rightarrow D_2$

		$D_2$						
		1	2	3	4	5	6	
D <sub>1</sub>		1	(1,1)	(1,2)	...	...	...	(1,6)
		2		(2,2)				
		3			(3,3)			
		4						
		5						
		6	(6,1)	...	...	...	(6,6)	

$= 6 \times 6$   
 $= 36$   
elements  
in SS

Sample Space =

$A \rightarrow C_1$        $V \rightarrow C_2$

Tossing two coins.

$C_1$	$C_2$
H	H
H	T
T	H
T	T

Sample Space = { HH, HT,  
TH, TT }.

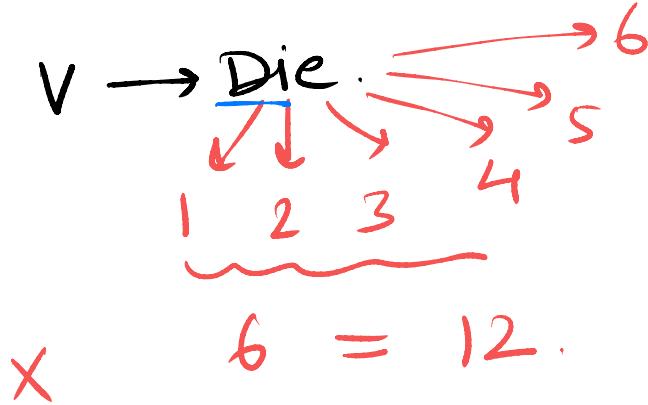
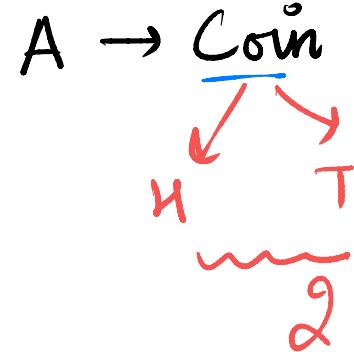
⇒ 4 elements

Event:

$E_1$  = At least 1 head = { HH, HT, TH }

$E_2$  = Both Same = { HH, TT }

## Mix Match



$$SS = \left\{ (H, 1), (H, 2), (H, 3), (H, 4), (H, 5), (H, 6), (T, 1), (T, 2), (T, 3), (T, 4), (T, 5), (T, 6) \right\}$$

Betting game: Dic SS :  $\{1, 2, 3, 4, 5, 6\}$

$$A \rightarrow \{1, 3, 5\} = E_1 \quad \checkmark$$

$$V \rightarrow \{1, 5, 6\} = E_2 \quad \xrightarrow{\text{(ARash and Vaibhav)}}$$

① Winning Together: (finding something common in  $E_1 \cap E_2$ )

$$E_1 \cap E_2 = \{1, 5\} \rightarrow \text{Intersection of Events}$$

② Anyone Wins (ARash or Vaibhav)

$$\{1, 3, 5, 6\} = E_1 \cup E_2 \rightarrow \text{Union of Events}$$

Set Operations \*

\*  $A \rightarrow \{1, 3, 5\} = E_1$     $V \rightarrow \{2, 4, 6\} = E_2$

$\Rightarrow E_1 \cap E_2 = \text{null} = \{\}$    "  $\emptyset$  "

[Mutually Exclusive Events]

(Disjoint Sets)

$$A \rightarrow \{1, 2\} = E_1 \quad V \rightarrow \{3, 4, 5, 6\} = E_2$$

$$SS = \{1, 2, 3, 4, 5, 6\}$$

$$E_1 + E_2 = SS$$

$E_2$  is compliment of  $E_1$  & vice versa.

$$E_2 = E_1^c$$

$$E_1 = E_2^c$$

Compliment

$$A \rightarrow \{1\}$$
$$V \rightarrow \{5\}$$

} mutually Exclusive ✓

$$A + V \rightarrow SS \cancel{X}$$

# Probability

Coin

= SS = {H, T} → 2 elements.

$E_1 \rightarrow$  getting a head  $\rightarrow E_1 = \{H\} \rightarrow 1 \text{ element}$ .

$$P(E_1) = \frac{\text{\# of elements in event space}}{\text{Total \# of elements in Sample Space}} = \frac{1}{2}$$

$$P(E_1) = \frac{1}{2} = 0.5 = 50\% \quad \checkmark$$

Die:  $SS = \{1, 2, 3, 4, 5, 6\}$

$E_1 = \text{odd } \#'s = \{1, 3, 5\} \Rightarrow P(E_1) = \frac{3}{6} = \frac{1}{2}$

$E_2 = \text{even } \#'s = \{2, 4, 6\} \Rightarrow P(E_2) = \frac{3}{6} = \frac{1}{2}$

$E_3 = \text{Perfect sq.} = \{1, 4\} \Rightarrow P(E_3) = \frac{2}{6} = \frac{1}{3}$

Die:  $SS = \{1, 2, 3, 4, 5, 6\}$

Akash

$$E_1 = \{1, 2, 3\}$$

$$P(E_1) = \frac{1}{2}$$

Vaibhav

$$E_2 = \{1, 4, 5\}$$

$$P(E_2) = \frac{1}{2}$$

$$\Rightarrow (E_1 \cap E_2) = \{1\} \Rightarrow P(E_1 \cap E_2) = \frac{1}{6}$$

$$\Rightarrow (E_1 \cup E_2) = \{1, 2, 3, 4, 5\} \Rightarrow P(E_1 \cup E_2) = \frac{5}{6}$$

Can I say:  $\underbrace{P(E_1 \cup E_2)}_{\downarrow 5/6} = \underbrace{P(E_1)}_{1/2} + \underbrace{P(E_2)}_{1/2} \rightarrow ?$

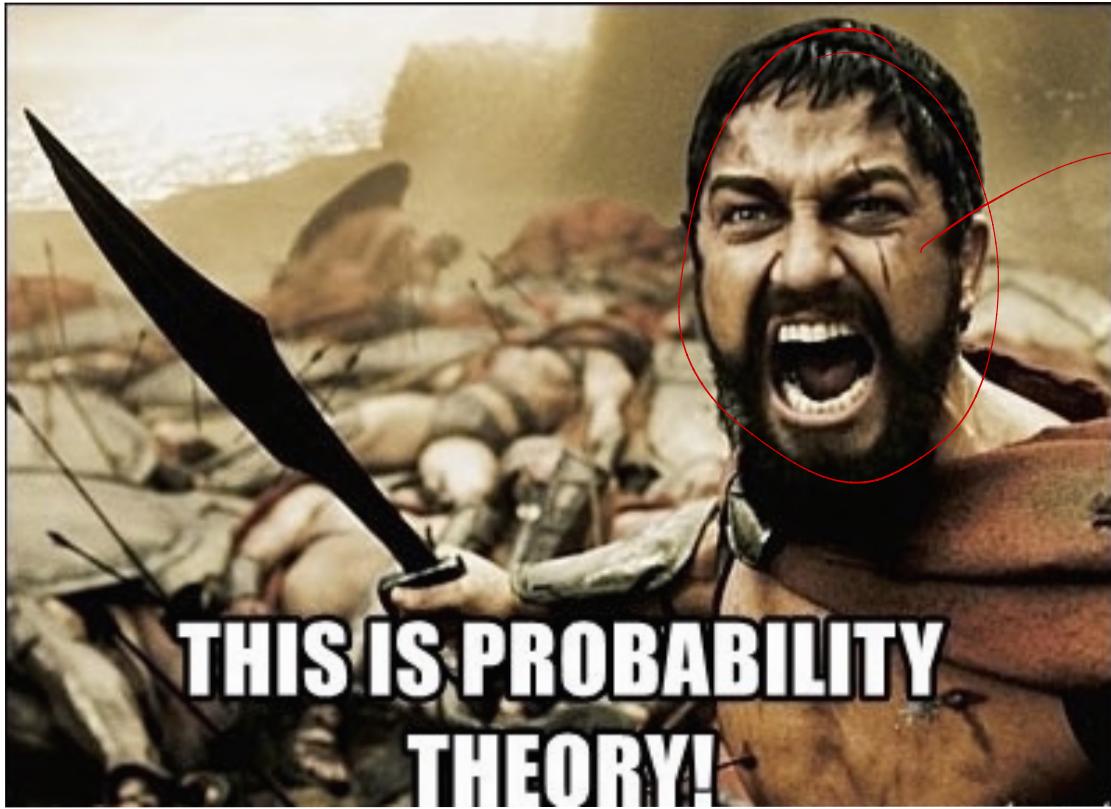
$$\frac{5}{6} \neq 1$$

$$P(E_1) + P(E_2) - P(\{1\})$$

$$\left(\frac{1}{2} + \frac{1}{2}\right) - \frac{1}{6} = 1 - \frac{1}{6} = \frac{5}{6}$$

$$P(E_1 \cup E_2) = P(E_1) + P(E_2) - P(E_1 \cap E_2)$$

→ Addition Rule of PROBABILITY ✓



THIS IS PROBABILITY  
THEORY!

exhaustive

→ Leonidas

300 movie \*