

TUTORIAL CO1: Probability – Addition, Multiplication, and Bayes' Theorem

Introduction

Probability is the chance that something will happen. We write it as $P(A)$, where A is an event.

- $P(A) = 1$ means it will surely happen
- $P(A) = 0$ means it will never happen
- $P(A) = 0.5$ means maybe it will happen

Question 1: What is the Addition Rule in Probability?

Answer:

The Addition Rule is used to find the probability that event A or event B happens.

Formula:

$$P(A \cup B) = P(A) + P(B) - P(A \cap B)$$

Explanation:

If A and B can happen at the same time, we subtract the overlap so it's not counted twice.

Math Example:

$$P(A) = 0.6 \text{ (chance of rain)}$$

$$P(B) = 0.5 \text{ (chance of thunder)}$$

$$P(A \cap B) = 0.3 \text{ (chance of both rain and thunder)}$$

$$P(A \cup B) = 0.6 + 0.5 - 0.3 = 0.8$$

Python Code:

$$P_A = 0.6$$

$$P_B = 0.5$$

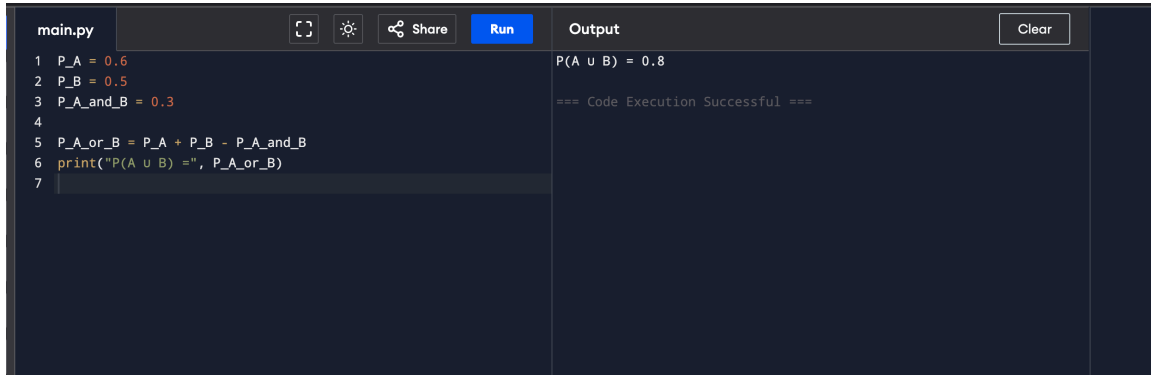
$$P_A_and_B = 0.3$$

$$P_A_or_B = P_A + P_B - P_A_and_B$$

```
print("P(A ∪ B) =", P_A_or_B)
```

Output:

$$P(A \cup B) = 0.8$$



```
main.py  [Run] [Share] [Clear]
1 P_A = 0.6
2 P_B = 0.5
3 P_A_and_B = 0.3
4
5 P_A_or_B = P_A + P_B - P_A_and_B
6 print("P(A u B) =", P_A_or_B)
7
```

P(A u B) = 0.8

=== Code Execution Successful ===

Question 2: What is the Multiplication Rule in Probability?

Answer:

The Multiplication Rule is used to find the probability that both A and B happen, written as $P(A \cap B)$.

There are two types of multiplication rules:

Case 1: Independent Events

Events that do not affect each other.

Formula:

$$P(A \cap B) = P(A) \times P(B)$$

Example:

$$P(A) = 0.6 \text{ (winning a toss)}$$

$$P(B) = 0.5 \text{ (winning a dice game)}$$

$$P(A \cap B) = 0.6 \times 0.5 = 0.3$$

Python Code:

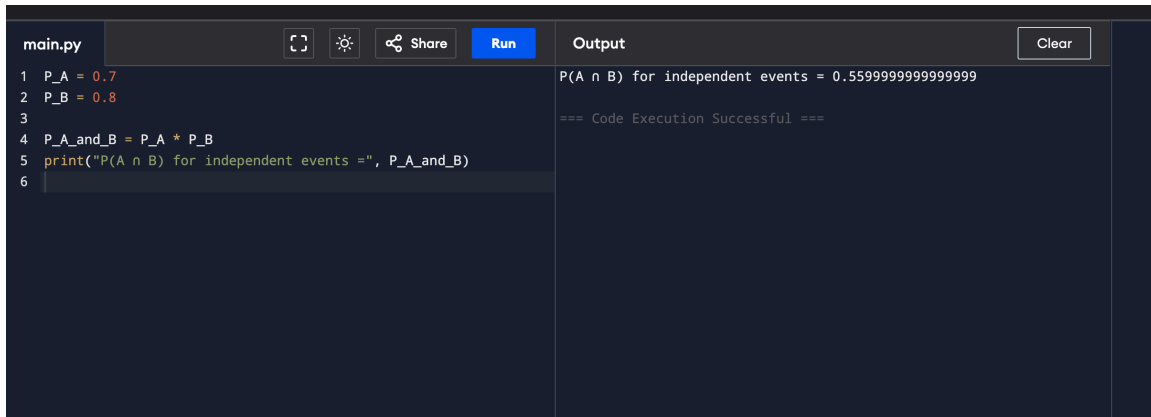
$$P_A = 0.6$$

$$P_B = 0.5$$

```
P_A_and_B = P_A * P_B
print("P(A ∩ B) =", P_A_and_B)
```

Output:

P(A ∩ B) = 0.3



The screenshot shows a Python IDE interface. On the left, a file named 'main.py' contains the following code:

```
1 P_A = 0.7
2 P_B = 0.8
3
4 P_A_and_B = P_A * P_B
5 print("P(A n B) for independent events =", P_A_and_B)
6
```

On the right, the 'Output' panel displays the result of the code execution:

```
P(A n B) for independent events = 0.5599999999999999
=== Code Execution Successful ===
```

Case 2: Dependent Events

Events where the outcome of A affects the outcome of B.

Formula:

$$P(A \cap B) = P(A) \times P(B | A)$$

Example:

P(A) = 0.4 (drawing red card first)

P(B | A) = 0.3 (drawing second red card after first)

$$P(A \cap B) = 0.4 \times 0.3 = 0.12$$

Python Code:

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P_A = 0.4

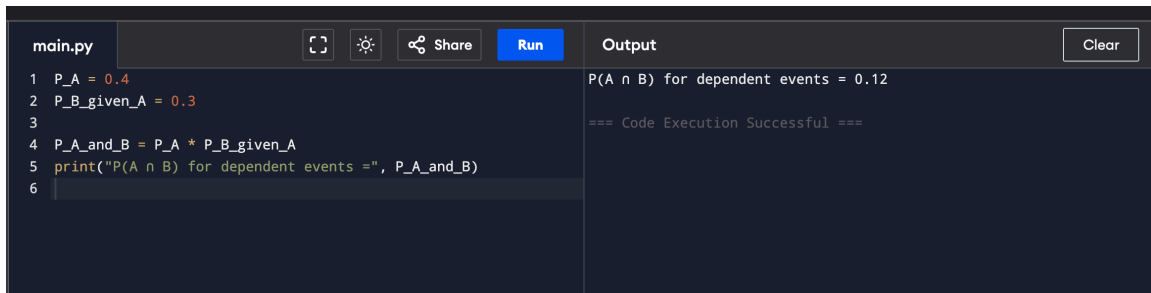
P_B_given_A = 0.3

P_A_and_B = P_A * P_B_given_A

print("P(A ∩ B) =", P_A_and_B)

Output:

P(A ∩ B) = 0.12



```
main.py
1 P_A = 0.4
2 P_B_given_A = 0.3
3
4 P_A_and_B = P_A * P_B_given_A
5 print("P(A ∩ B) for dependent events =", P_A_and_B)
6
```

Output

P(A ∩ B) for dependent events = 0.12

=== Code Execution Successful ===

Question 3: What is Bayes' Theorem in Probability?

Answer:

Bayes' Theorem helps to find the reverse probability — the chance of event A happening given that B has already happened.

Formula:

$P(A | B) = [P(B | A) \times P(A)] / P(B)$

Explanation:

It is useful when we already know the result (B), and want to find out the real cause (A).

Math Example:

P(A) = 0.01 (has disease)

P(B | A) = 0.95 (test positive if sick)

P(B) = 0.05 (test positive overall)

$P(A | B) = (0.95 \times 0.01) / 0.05 = 0.19$

Python Code:

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P_A = 0.01

P_B_given_A = 0.95

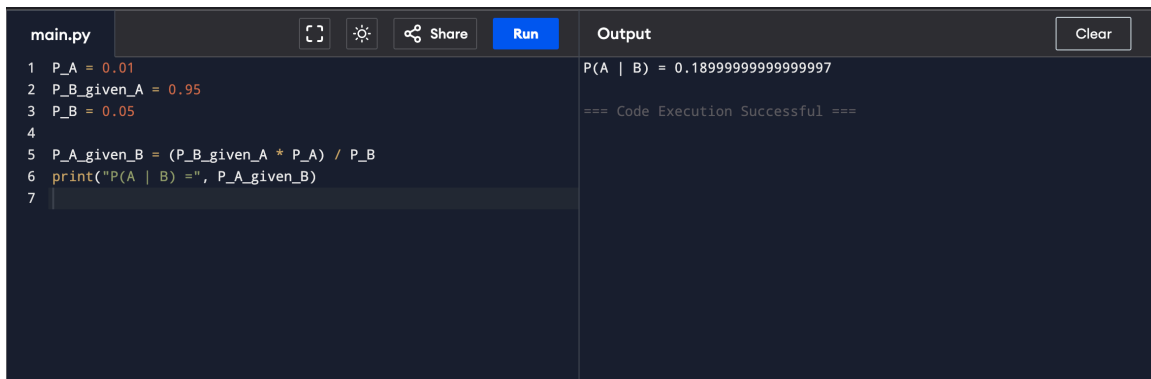
P_B = 0.05

P_A_given_B = (P_B_given_A * P_A) / P_B

print("P(A | B) =", P_A_given_B)

Output:

P(A | B) = 0.19



The screenshot shows a code editor with a dark theme. The left pane contains a file named 'main.py' with the following Python code:

```
1 P_A = 0.01
2 P_B_given_A = 0.95
3 P_B = 0.05
4
5 P_A_given_B = (P_B_given_A * P_A) / P_B
6 print("P(A | B) =", P_A_given_B)
7
```

The right pane, titled 'Output', shows the result of the code execution:

```
P(A | B) = 0.18999999999999997
=== Code Execution Successful ===
```

At the top of the editor, there are icons for file operations and a 'Run' button. A 'Clear' button is located at the top right of the output pane.