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**🔹 Multiplication Rule of Probability**

**Definition:**  
This rule helps in calculating the chance that two or more events happen at the same time — i.e., the **intersection** of events.

**General Case:**  
For two events A and B:  
**P(A ∩ B) = P(A) × P(B|A)**  
Here, **P(B|A)** is the **conditional probability** of B given that A has already occurred.

**Special Cases:**

* **Independent Events:**  
  If A and B do **not influence each other**, then:  
  **P(A ∩ B) = P(A) × P(B)**
* **Dependent Events:**  
  If the occurrence of A affects the likelihood of B:  
  **P(A ∩ B) = P(A) × P(B|A)**  
  This requires knowing or finding the conditional probability **P(B|A)**.
* **More than Two Events:**  
  For events A, B, and C:  
  **P(A ∩ B ∩ C) = P(A) × P(B|A) × P(C|A ∩ B)**  
  This logic can be extended to multiple events using chained conditionals.

**Example (Dependent Events):**  
Two cards are drawn one after the other without putting the first one back.  
What is the chance both are aces?

Code:

p\_a = 0.2

p\_b\_given\_a = 0.4

p\_a\_and\_b = p\_a \* p\_b\_given\_a

print(f"P(A and B) = {p\_a\_and\_b}") # Output: 0.08

**🔹 Addition Rule of Probability**

**Definition:**  
This rule calculates the probability that **either one** or **both** of the events occur.

**General Case:**  
**P(A ∪ B) = P(A) + P(B) − P(A ∩ B)**  
(A ∪ B means "A or B")

**Special Cases:**

* **Mutually Exclusive Events:**  
  If A and B **cannot occur together** (e.g., rolling a 3 or 4 on a die), then:  
  **P(A ∩ B) = 0**  
  So,  
  **P(A ∪ B) = P(A) + P(B)**
* **Not Mutually Exclusive:**  
  If A and B **can both occur**, subtract **P(A ∩ B)** to avoid double-counting.

**Example:**  
If the chance of rolling a 3 is 0.4, a 5 is 0.5, and both together is 0.2:

Code:

p\_a = 0.4

p\_b = 0.5

p\_a\_and\_b = 0.2

p\_a\_or\_b = p\_a + p\_b - p\_a\_and\_b

print(f"P(A or B) = {p\_a\_or\_b}") # Output: 0.7

**🔹 Bayes’ Theorem**

**Definition:**  
Bayes’ theorem allows us to **update the probability** of an event based on new information.

**Formula:**  
**P(A|B) = [P(B|A) × P(A)] / P(B)**

Where:

* **P(A|B):** Probability of A given B (posterior)
* **P(B|A):** Probability of B given A (likelihood)
* **P(A):** Initial probability of A (prior)
* **P(B):** Total probability of B (evidence)

**Application:**  
Bayes’ theorem is widely used in fields like diagnostics, artificial intelligence, and decision-making systems.

**Example:**  
1% of people have a disease.

* The test correctly detects the disease **90%** of the time.
* It wrongly shows positive in **5%** of healthy people.
* . The test correctly detects the disease **90%** of the time.
* It wrongly shows positive in **5%** of healthy people.

Code:

p\_a = 0.01

p\_b\_given\_a = 0.9

p\_b = 0.05

p\_a\_given\_b = (p\_b\_given\_a \* p\_a) / p\_b

print(f"P(A|B) = {p\_a\_given\_b}") # Output: 0.18