DSS TUTORIAL

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* **Probability Multiplication Rule**

**Definition:**  
The multiplication rule relates to finding the probability that **multiple events happen together**—that is, the intersection of two or more events.

**General Case:**  
For any two events A and B,

P(A∩B)=P(A)×P(B∣A)*P*(*A*∩*B*)=*P*(*A*)×*P*(*B*∣*A*)

where P(B∣A)*P*(*B*∣*A*) is the **conditional probability** of B occurring given that A has already occurred.

**Special Cases**

* **Independent Events:**  
  If A and B are independent (the outcome of one does not influence the other):

P(A∩B)=P(A)×P(B)*P*(*A*∩*B*)=*P*(*A*)×*P*(*B*)

This formula applies whenever events do not affect each other’s likelihood.

* **Dependent Events:**  
  If A and B are dependent (the chance of B can change when A occurs):

P(A∩B)=P(A)×P(B∣A)*P*(*A*∩*B*)=*P*(*A*)×*P*(*B*∣*A*)

Here, you must know or calculate P(B∣A)*P*(*B*∣*A*)—the chance that B occurs in scenarios where A has already happened.

* **More than Two Events:**  
  For events A, B, and C:

P(A∩B∩C)=P(A)×P(B∣A)×P(C∣A∩B)*P*(*A*∩*B*∩*C*)=*P*(*A*)×*P*(*B*∣*A*)×*P*(*C*∣*A*∩*B*)

This can be extended to more events by chaining conditional probabilities.

**Dependent Events Example**

**Scenario:**  
You're drawing two cards from a standard deck, one after the other, without replacement.

* What is the probability both cards are aces?

CODE:

p\_a = 0.18

p\_b = 0.42

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

print(f"P(A and B) = {p\_a\_and\_b}") # Output: 0.0756

**Inputs:**

* p\_a: 0.2
* p\_b\_given\_a: 0.4

**Output:**

* P(A and B) = 0.08
* **Probability Addition Rule**

**Definition:**  
The addition rule addresses the probability that **at least one of two events** occurs: either A or B (or both).

**General Case:**

P(A∪B)=P(A)+P(B)−P(A∩B)*P*(*A*∪*B*)=*P*(*A*)+*P*(*B*)−*P*(*A*∩*B*)

(A∪B*A*∪*B* means "A or B"—the union).

**Special Cases**

* **Mutually Exclusive Events:**  
  If A and B cannot both occur at once (e.g., rolling a 1 or rolling a 2 in a single dice roll), then P(A∩B)=0*P*(*A*∩*B*)=0 and the rule simplifies to:

P(A∪B)=P(A)+P(B)*P*(*A*∪*B*)=*P*(*A*)+*P*(*B*)

* **Not Mutually Exclusive:**  
  If A and B can both happen, subtract their overlap, P(A∩B)*P*(*A*∩*B*), to avoid double-counting.

**Example:**

**Scenario:**  
Rolling a die, what's the chance of getting either a 3 **or** a 5?

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}")

**Inputs:**

* p\_a: 0.4
* p\_b: 0.5
* p\_a\_and\_b: 0.2

**Output:**

* P(A or B) = 0.7
* **Bayes’ Theorem**

**Definition:**  
Bayes’ theorem connects conditional probabilities, allowing you to update beliefs about an event based on new evidence.

**Formula:**

P(A∣B)=P(B∣A)×P(A)P(B)*P*(*A*∣*B*)=*P*(*B*)*P*(*B*∣*A*)×*P*(*A*)

Here,

* P(A∣B)*P*(*A*∣*B*): Probability of A given B is true (posterior)
* P(B∣A)*P*(*B*∣*A*): Probability of B given A is true (likelihood)
* P(A)*P*(*A*): Probability of A (prior)
* P(B)*P*(*B*): Probability of B (marginal likelihood)

**Usefulness:**  
Bayes’ theorem is used to **reverse conditional probabilities** and is foundational in statistics, machine learning, medical testing, and more.

Example:

**Scenario:**  
1% of people have a certain disease.  
The test for the disease is 90% accurate (if you have the disease, it finds it 90% of the time).  
But the test gives false positives 5% of the time (5% of healthy people test positive).

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}")

**Inputs:**

* p\_a: 0.01
* p\_b\_given\_a: 0.9
* p\_b: 0.05

**Inputs:**

* P(A|B) = 0.18