**1. Counting Sort**

**History: Developed by Harold H. Seward in the early 1950s (often cited around 1954).Recognized for its ability to sort integers in linear time under the right conditions.**

**Definition: Counting Sort is a non-comparison-based sorting algorithm that sorts elements by counting the number of occurrences of each unique value in the input array. It then uses these counts to determine the positions of each element in the final, sorted array.**

* **The algorithm operates in linear time,**
* **Time complexity: O(n + k), where n is the number of elements and k is the range of the input values**

**Algorithm:**

1. **Determine the Range:Find the minimum and maximum values in the input array to determine the range of the data. (Sometimes min is assumed to be 0 to simplify the process.)**
2. **Initialize the Count Array:Create a count array of size (max - min + 1) and initialize all elements to 0.**
3. **Count the Occurrences:Iterate over the input array and for each element, increment the corresponding index in the count array. For an element x, increment count[x-min].**
4. **Transform the Count Array into a Cumulative Count Array:Modify the count array such that each element at index i contains the sum of previous counts. This cumulative count tells you the final position of each element in the output array.**
5. **Build the Output Array:**

* **Traverse the input array once more, usually in reverse order to ensure stability (maintaining the original order of equal elements).**
* **Place each element x into its correct position in the output array by using the cumulative count, then decrement the count value for x.**

**Stability**

* **Stable: Maintains the relative order of equal elements if implemented correctly.**

**Complexity**

* **Time Complexity: O(n + k), where nn is the number of elements and kk is the range of values.**
* **Space Complexity: O(n + k) due to the need for count and output arrays.**

**Pros**

* **Linear Time: Highly efficient when the value range is not significantly larger than the number of elements.**
* **Simple and Easy to Implement.**
* **Stable.**

**Cons**

* **Memory Intensive: Requires significant extra memory when the value range kk is large.**
* **Not Flexible: Primarily suitable for integers or discrete values.**
* **Inefficient for Wide Value Range: Less effective for data with a wide range of values.**