NSGA 2: This algorithm follows the process shown in the diagram, ensuring efficient convergence towards the Pareto-optimal solutions.



1. **Initialize Population**
   * Generate an initial population P0P\_0 of size NN.
   * Evaluate all objective functions for each individual in the population.
2. **Non-Dominated Sorting**
   * Rank the population based on non-dominating criteria.
3. **Check Termination Criteria**
   * If termination criteria are met (e.g., max generations reached), output the **Pareto-optimal solution** and stop.
   * Otherwise, proceed to the next step.
4. **Generate Offspring Population**
   * Apply **Selection**, **Crossover**, and **Mutation** operators to create offspring population QtQ\_t.
5. **Evaluate New Population**
   * Compute objective functions for all individuals in QtQ\_t.
6. **Combine Populations**
   * Combine old parent population PtP\_t and offspring population QtQ\_t to form a new population Rt=Pt∪QtR\_t = P\_t \cup Q\_t.
7. **Non-Dominated Sorting on Combined Population**
   * Rank the individuals in RtR\_t based on **non-domination criteria**.
8. **Calculate Crowding Distance**
   * Compute the crowding distance of all individuals in RtR\_t.
9. **Select the Best NN Individuals**
   * Select the top NN individuals from RtR\_t based on **rank** and **crowding distance**.
10. **Replace Parent Population**
    * Set Pt+1P\_{t+1} as the newly selected best NN individuals.
11. **Repeat Steps 3-10**
    * Continue until termination criteria are met.
12. **Return Pareto-Optimal Solutions**
    * Output the final non-dominated set of solutions as the **Pareto-optimal front**.

**Conclusion**

NSGA-II is a powerful and widely used multi-objective optimization algorithm that efficiently finds a diverse set of Pareto-optimal solutions. By utilizing **non-dominated sorting**, **crowding distance**, and **elitism**, NSGA-II ensures that solutions converge towards the Pareto front while maintaining diversity.

Key advantages of NSGA-II include:  
**Fast non-dominated sorting** – Efficiently ranks individuals based on Pareto dominance.  
**Diversity preservation** – Uses crowding distance to maintain a well-distributed solution set.  
**Elitism** – Ensures that high-quality solutions are retained across generations.

Due to these strengths, NSGA-II is widely applied in fields such as engineering design, machine learning, scheduling, and financial optimization. By following the structured process shown in the flowchart, the algorithm systematically refines the population to approximate the best trade-off solutions for conflicting objectives.Thus, NSGA-II remains a benchmark algorithm for solving complex multi-objective optimization problems efficiently.