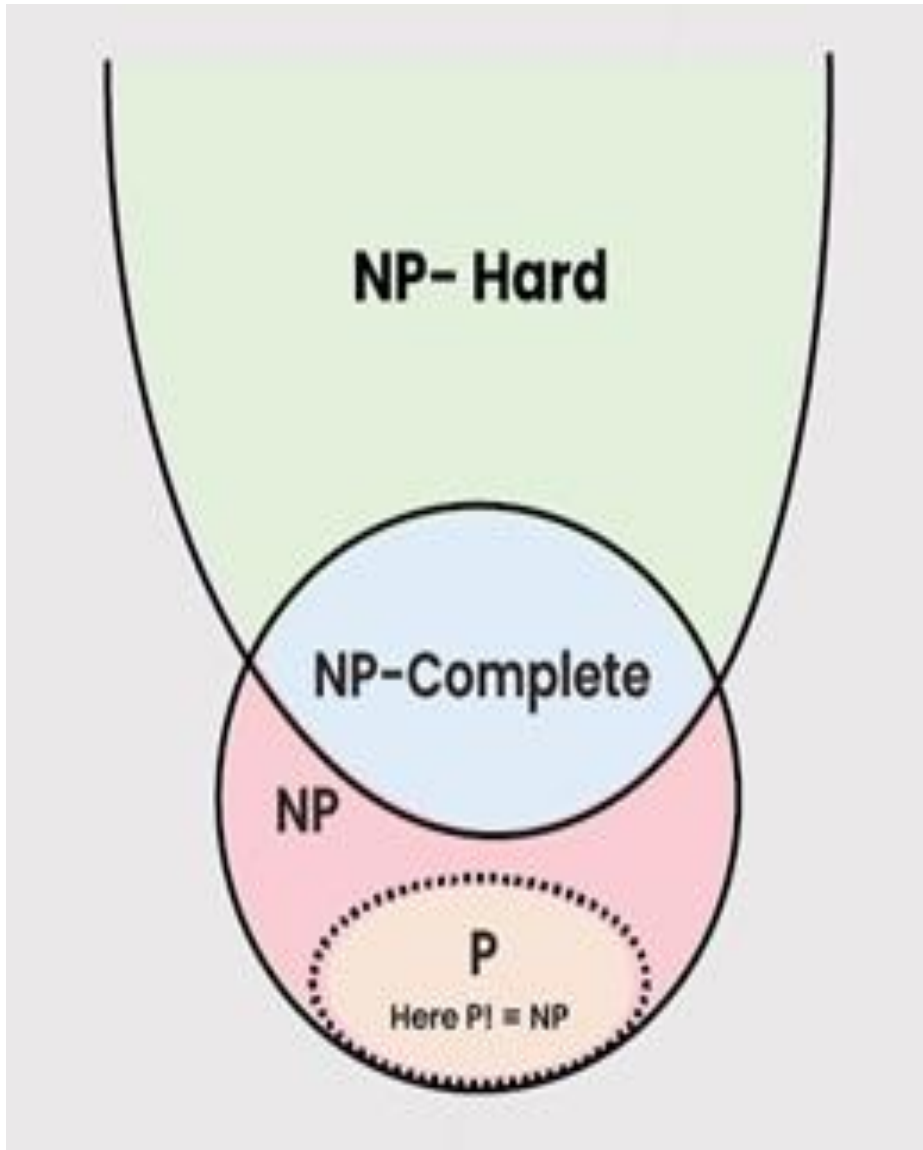


Types Of Complexity Classes

P, NP, NP-Hard and NP-
Complete, Problems

Types of Complexity Classes



- P Class
- NP Class
- CoNP Class
- NP-hard
- NP-complete

P, NP, NP-Hard and NP-Complete

Based on Time Complexity:

1) Polynomial Time Algorithms: (Time complexity is less)

Ex: Linear Search $O(n)$, Bubble Sort ($O(n^2)$), Merge Sort ($O(n \log n)$), etc

2) Non-Polynomial (or) Exponential Algorithms: (Time complexity is high)

Ex: Travelling Salesman Problem ($O(n^2 \cdot 2^n)$), Knapsack problem ($O(2^{n/2})$)

Based on Result:

- Decision problems
 - Result is yes or no $\{0,1\}$
- Optimization problems
 - Result is a number representing an objective value.

P, NP, NP-Hard and NP-Complete

P Class – Problem:

- P is set of problems that can be solved (deterministic) in Polynomial [P] Time.

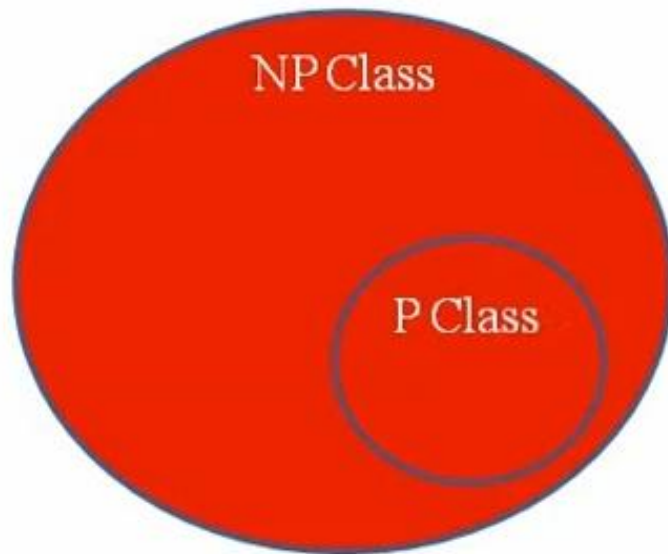
Example: Linear Search ($O(n)$), Binary Search ($O(\log n)$), etc

- Formally, an algorithm is polynomial time algorithm, if there exists a polynomial $p(n)$ such that the algorithm can solve any instance of size n in a time $O(p(n))$.

NP Class – Problem:

- NP is set of problems that can be solved (non-deterministic) in exponential (Non-deterministic Polynomial [NP]) Time.
- But these kind of problem can be verified in Polynomial Time.

Example: Travelling Salesman Problem



NP – Class:

- Solved in Non-Polynomial Time
- Verified in Polynomial Time
- Intractable Problem

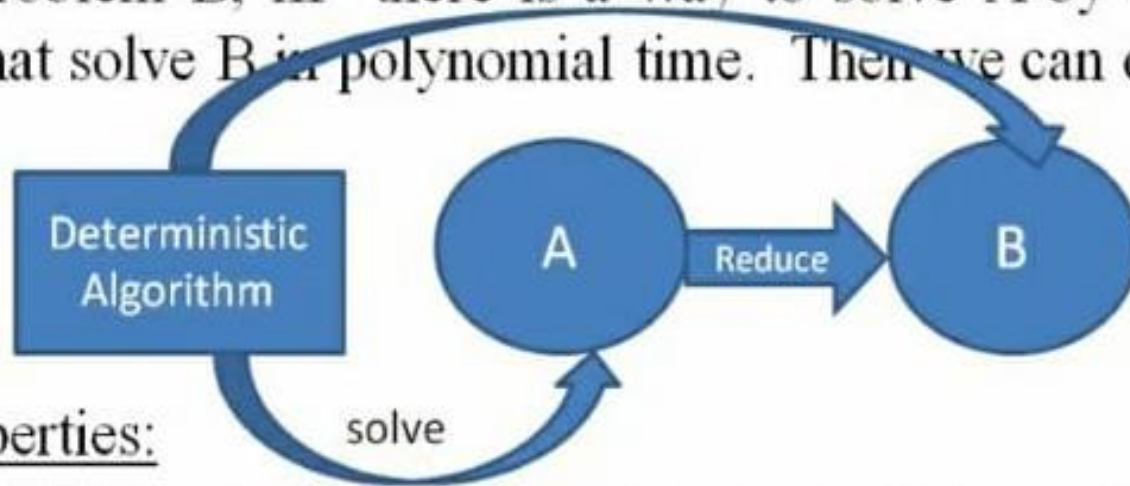
P – Class:

- Solved in Polynomial Time
- Verified in Polynomial Time
- Tractable Problem

- P class problems are subset of NP class problem
- It's not known whether $P=NP$
- $P \neq NP$

Reduction:

- Let A and B are two problems in NP. If problem A is reduce to problem B, iff there is a way to solve A by deterministic algorithm that solve B in polynomial time. Then we can denote $A \leq B$.

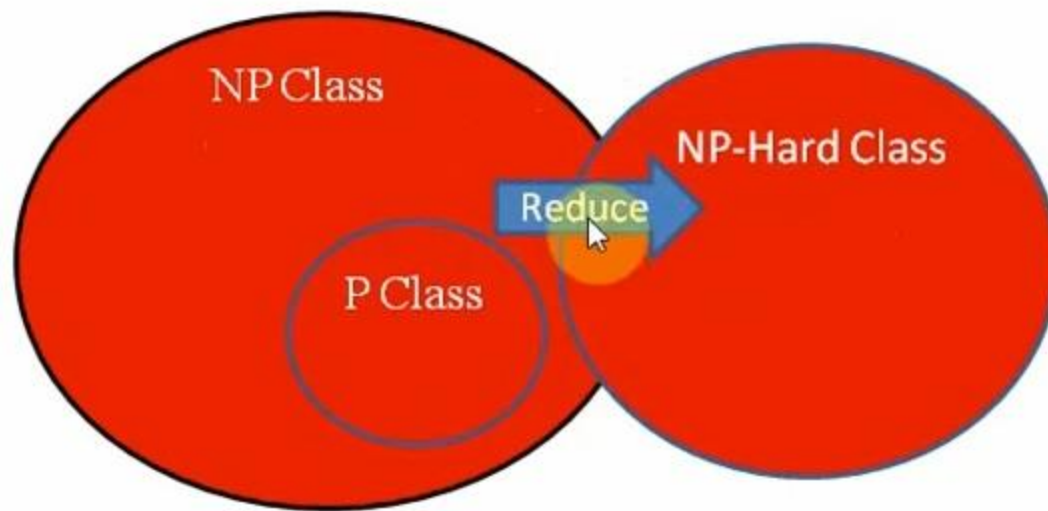


Properties:

- If A is reducible to B and B is in Polynomial time, then A also in Polynomial time.
- A is not in Polynomial time, it implies that B is not in Polynomial time.

NP-Hard Problem:

- Every problem in NP class can be reduced into other set using polynomial time, then its called as NP-Hard problem.



NP-Complete Problem:

- The group of problems which are both in NP and NP-hard are known as NP-Complete problem.
- All NP-Complete problems are NP-Hard but not all NP-Hard problems are not NP-Complete problem.

