

-Basic Geometry/Euclidean Geometry/ordinate Geometry/[3-D variants of everything].

### 1. Computational Geometry.

Graham Scan algorithm for Convex Hull  $O(n * \log(n))$ .

a. Online construction of 3-D convex hull in  $O(n^2)$ .

b. Bentley Ottmann algorithm to list all intersection points of  $n$  line segments in  $O((n + I) * \log n)$ .

■ Suggested Reading -

1. [http://softsurfer.com/Archive/algorithm\\_0108/algorithm\\_0108.htm](http://softsurfer.com/Archive/algorithm_0108/algorithm_0108.htm)

c. Rotating Calipers Technique.

■ Suggested Reading - <http://cgm.cs.mcgill.ca/~orm/rotcal.html>

■ Problems - Refer the article for a list of problems which can be solved using Rotating Calipers technique.

d. Line Sweep/Plane Sweep algorithms -

■ Area/Perimeter of Union of Rectangles.

■ Closest pair of points.

■ Suggested Reading -

1. <http://www.topcoder.com/tc?module=Static&dl=tutorials&d2=lineSweep>

■ Problems - Follow the tutorial for list of problems.

e. Area of Union of Circles.

f. Delaunay Triangulation of  $n$  points in  $O(n * \log n)$ .

g. Voronoi Diagrams of  $n$  points in  $O(n * \log n)$  using Fortune's algorithm.

h. Point in a polygon problem -

■  $O(n)$  solution without preprocessing.

■  $O(\log n)$  algorithm with  $O(n * \log n)$  preprocessing for convex polygons.

i. Problems on computational geometry -

■ [BSHEEP](#), [BULK](#), [SEGVIS](#), [CONDUIT](#), [RUNAWAY](#), [DIRVS](#), [RAIN1](#), [SHAMAN](#), [TCUTTER](#), [LITEPIPE](#), [RHOMBS](#), [FSHEEP](#), [FLBRKLIN](#), [CERC07P](#), [BAC](#), [ALTARS](#), [CERC07C](#), [NECKLACE](#), [CH3D](#), [RECTANGL](#), [POLYSSO](#), [FOREST2](#), [KPPOLY](#), [RAIN2](#), [SEGMENTS](#), [ARCHPLG](#), [BALLOON](#), [CIRCLES](#), [COMPASS](#), [EOWAMRT](#), [ICERINK](#) on SPOJ.

■ [CultureGrowth](#), [PolygonCover](#) on Topcoder.

j. Suggested Reading -

■ Computational Geometry: Algorithms and applications. Mark De Burg.

To be Done till 6th may.

■ **String Algorithm.**

1. **KnuthMorrisPratt** algorithm.

a. Problems - NHAY, PERIOD on SPOJ.

b. Suggested Reading -

i. Cormen chapter on Strings.

ii. <http://www.topcoder.com/tc?module=Static&dl=tutorials&d2=stringSearching>

2. Aho Corasick algorithm.

2. Problems - WPUZZLES on SPOJ.

a. Suffix Arrays

■  $O(n^2 * \log n)$  Naive method of suffix array construction

■  $O(n * \log n^2)$  method of suffix array construction

■  $O(n * \log n)$  method of suffix array construction.

■  **$O(n)$**  method of suffix array construction

■  $O(n)$  LCA preprocess on Suffix Arrays to solve a variety of string problems.

b. Suffix Trees

■  $O(n)$  construction of Suffix trees using Ukkonon's algorithm.

■  $O(n)$  construction of Suffix Trees if provided with Suffix Arrays using Farach's algorithm.

c. Suffix Automata

■  $O(n)$  Suffix Automaton construction.

d. Dictionary Of Basic Factors

■  $O(n * \log n)$  method of DBF construction using Radix Sort.

e. **Manacher's algorithm** to find length of palindromic substring of a string centered at a position for each position in the string. Runtime  $\rightarrow O(n)$ .

f. Searching and preprocessing Regular Expressions consisting of '?', '\*'.

g. Multi-dimensional pattern matching.

h. Problems on Strings [can be solved with a variety of techniques] -

■ [DISUBSTR](#), [PLD](#), [MSTRING](#), [REPEATS](#), [JEWELS](#), [ARCHIVER](#), [PROPKEY](#), [LITELANG](#), [EMOTICON](#), [WORDS](#), [AMCODES](#), [UCODES](#), [PT07H](#), [MINSEQ](#), [TOPALIN](#), [BWHEELER](#), [BEADS](#), [SARRAY](#), [LCS](#), [LCS2](#), [SUBST1](#), [PHRASES](#), [PRETILE](#) on SPOJ

■ [http://www.algorithmist.com/index.php/Category:String\\_algorithms](http://www.algorithmist.com/index.php/Category:String_algorithms)

Till 11 may.

### 3. Basic Graphs [beginner].

a. Representation of graphs as adjacency list, adjacency matrix, incidence matrix and edge list and uses of different representations in different scenarios.

b. Breadth First Search.

- problems -
  1. [PPATH](#), [ONEZERO](#), [WATER](#) on SPOJ
- c. Depth First Search.
- d. Strongly Connected Components.
  - problems -
    1. TOUR and [BOTTOM](#) on SPOJ.
- e. Biconnected Components, Finding articulation points and bridges].
  - problems -
    1. [RELINETS](#), [PT07A](#) on SPOJ.
- f. Dijkstra algorithm -
  - problems -
    1. [SHPATH](#) on SPOJ.
- g. Floyd Warshall algorithm -
  - problems -
    1. [COURIER](#) on SPOJ.
- h. Minimum Spanning Tree
  - problems -
    1. [BLINNET](#) on SPOJ.
- i. Flood-fill algorithm
- j. Topological sort
- k. Bellman-Ford algorithm.
- l. Euler Tour/Path.
  - problems - [WORDS1](#) on SPOJ.
- m. Suggested reading for most of the topics in Graph algorithms -
  - <http://www.topcoder.com/tc?module=Static&dl=tutorials&d2=graphsDataStrucs1>.
  - Also refer to the tutorial for problems concerning these techniques.
  - Corman chapter 22 to 24.

Till 13 may. (before coming iitk it should be done :))

#### 4. Flow networks/ matching etc etc. [Intermediate/Advanced].

- a. Maximum flow using Ford Fulkerson Method.
  - Suggested Reading -
    1. <http://www.topcoder.com/tc?module=Static&dl=tutorials&d2=maxFlow>
  - problems - [TAXI](#), [POTHOLE](#), [IM](#), [QUEST4](#), [MUDDY](#), [EN](#), [CABLETV](#), [STEAD](#), [NETADMIN](#), [COCONUTS](#), [OPTM](#) on SPOJ.
- b. Maximum flow using Dinic's Algorithm.
  - Problems - [PROFIT](#) on spoj.
- c. Minimum Cost Maximum Flow.
  - Successive Shortest path algorithm.
  - Cycle Cancelling algorithm.
  - Suggested Reading -
    1. <http://www.topcoder.com/tc?module=Static&dl=tutorials&d2=minimumCostFlow1>
- d. Maximum weighted Bipartite Matching (Kuhn Munkras algorithm/Hungarian Method)
  - problems - [GREED](#), [SCITIES](#), [TOURS](#) on SPOJ | [http://www.topcoder.com/stat?c=problem\\_statement&pm=8143](http://www.topcoder.com/stat?c=problem_statement&pm=8143)
- e. Stoer Wagner min-cut algorithm.
- f. Hopcroft Karp bipartite matching algorithm.
  1. problems - [ANGELS](#) on SPOJ.
- g. Maximum matching in general graph (blossom shrinking)
- h. Gomory-Hu Trees.aa
  - i) Problems - [MCOQUERY](#) on Spoj.
- i. Chinese Postman Problem.
  - problems - <http://acm.uva.es/archive/nuevoportal/data/problem.php?p=4039>
  - Suggested Reading - <http://eie507.eie.polyu.edu.hk/ss-submission/B7a/>
- j. Suggested Reading for the full category ->
  - Network flow - Algorithms and Applications by Ahuja
  - Corman book chapter 25.

Till 20 th may.

#### 5. Dynamic Programming.

- a. Suggested Reading - Dynamic Programming(DP) as a tabulation method
  - Corman chapter on DP
- b. Standard problems (you should really feel comfortable with these types)
  - [http://www.topcoder.com/stat?c=problem\\_statement&pm=8570&rd=12012&rm=269199&cr=7581406](http://www.topcoder.com/stat?c=problem_statement&pm=8570&rd=12012&rm=269199&cr=7581406)
  - [http://www.topcoder.com/stat?c=problem\\_statement&pm=10765&rd=14183](http://www.topcoder.com/stat?c=problem_statement&pm=10765&rd=14183)
- c. State space reduction
  - [http://www.topcoder.com/stat?c=problem\\_statement&pm=10902](http://www.topcoder.com/stat?c=problem_statement&pm=10902)
  - [http://www.topcoder.com/stat?c=problem\\_statement&pm=3001](http://www.topcoder.com/stat?c=problem_statement&pm=3001)
  - [http://www.topcoder.com/stat?c=problem\\_statement&pm=8605&rd=12012&rm=269199&cr=7581406](http://www.topcoder.com/stat?c=problem_statement&pm=8605&rd=12012&rm=269199&cr=7581406)
- d. Solving in the reverse - easier characterizations looking from the end
  - <http://www.spoj.pl/problems/MUSKET>
  - [http://www.topcoder.com/stat?c=problem\\_statement&pm=5908](http://www.topcoder.com/stat?c=problem_statement&pm=5908)
- e. Counting/optimizing arrangements satisfying some specified properties

- [http://www.topcoder.com/stat?c=problem\\_statement&pm=8306](http://www.topcoder.com/stat?c=problem_statement&pm=8306)
- [http://www.topcoder.com/stat?c=problem\\_statement&pm=784](http://www.topcoder.com/stat?c=problem_statement&pm=784)
- 9 Strategies and expected values
- [http://www.topcoder.com/stat?c=problem\\_statement&pm=10765&rd=14183](http://www.topcoder.com/stat?c=problem_statement&pm=10765&rd=14183)
- [http://www.topcoder.com/stat?c=problem\\_statement&pm=10806](http://www.topcoder.com/stat?c=problem_statement&pm=10806)
- [http://www.topcoder.com/stat?c=problem\\_statement&pm=7828](http://www.topcoder.com/stat?c=problem_statement&pm=7828)
- [http://www.topcoder.com/stat?c=problem\\_statement&pm=7316](http://www.topcoder.com/stat?c=problem_statement&pm=7316)
- f. DP on probability spaces
  - [http://www.topcoder.com/stat?c=problem\\_statement&pm=7422](http://www.topcoder.com/stat?c=problem_statement&pm=7422)
  - [http://www.topcoder.com/stat?c=problem\\_statement&pm=2959](http://www.topcoder.com/stat?c=problem_statement&pm=2959)
  - [http://www.topcoder.com/stat?c=problem\\_statement&pm=10335](http://www.topcoder.com/stat?c=problem_statement&pm=10335)
- g. DP on trees
  - [http://www.topcoder.com/stat?c=problem\\_statement&pm=10800](http://www.topcoder.com/stat?c=problem_statement&pm=10800)
  - [http://www.topcoder.com/stat?c=problem\\_statement&pm=10737](http://www.topcoder.com/stat?c=problem_statement&pm=10737)
  - [http://www.topcoder.com/stat?c=problem\\_solution&rm=266678&rd=10958&pm=8266&cr=7581406](http://www.topcoder.com/stat?c=problem_solution&rm=266678&rd=10958&pm=8266&cr=7581406)
- h. DP with data structures
  - <http://www.spoj.pl/problems/INCSEQ/>
  - <http://www.spoj.pl/problems/INCDSEQ/>
  - <http://www.spoj.pl/problems/LIS2/>
  - [http://www.topcoder.com/stat?c=problem\\_statement&pm=1986](http://www.topcoder.com/stat?c=problem_statement&pm=1986)
- i. Symmetric characterization of DP state
  - [http://www.topcoder.com/stat?c=problem\\_statement&pm=8610](http://www.topcoder.com/stat?c=problem_statement&pm=8610)
- j. A good collection of problems
  - <http://codeforces.com/blog/entry/325>
  - <http://problemclassifier.appspot.com/index.jsp?search=dp&usr=>

Till 28 th may.

## 6. Greedy.

- a. Suggested Reading -
  - Chapter on Greedy algorithms in Cormen.
  - <http://www.topcoder.com/tc?module=Static&d1=tutorials&d2=greedyAlg>
- b. problems - refer to the topcoder tutorial.

## 7. Number Theory.

- a. Modulus arithmetic - basic postulates [Including modular linear equations, Continued fraction and Pell's equation]
  - Suggested Reading -
    1. Chapter 1 from Number Theory for Computing by SY Yan [ Recommended ]
    2. 31.1, 31.3 and 31.4 from Cormen
    3. [www.topcoder.com/tc?module=Static&d1=tutorials&d2=primeNumbers](http://www.topcoder.com/tc?module=Static&d1=tutorials&d2=primeNumbers)
  - Problems
    1. <http://projecteuler.net/index.php?section=problems&id=64>
    2. <http://projecteuler.net/index.php?section=problems&id=65>
    3. <http://projecteuler.net/index.php?section=problems&id=66>
    4. [http://www.topcoder.com/stat?c=problem\\_statement&pm=6408&rd=9826](http://www.topcoder.com/stat?c=problem_statement&pm=6408&rd=9826)
    5. [http://www.topcoder.com/stat?c=problem\\_statement&pm=2342](http://www.topcoder.com/stat?c=problem_statement&pm=2342)
- b. Fermat's theorem, Euler's Totient theorem ( totient function, order , primitive roots )
  - Suggested Reading
    1. 1.6, 2.2 from Number Theory by SY Yan
    2. 31.6 , 31.7 from Cormen
  - Problems
    1. <http://projecteuler.net/index.php?section=problems&id=70>
    2. <http://www.spoj.pl/problems/NDIVPHI/>
- c. Chinese remainder theorem
  - Suggested Reading
    1. 31.5 from Cormen
    2. 1.6 from Number Theory by SY Yan
  - Problems
    1. Project Euler 271
    2. [http://www.topcoder.com/stat?c=problem\\_statement&pm=10551&rd=13903](http://www.topcoder.com/stat?c=problem_statement&pm=10551&rd=13903)
- d. Primality tests -
  - Deterministic  $O(\sqrt{n})$  approach
  - Probabilistic primality tests - Fermat primality test, Miller-Rabin Primality test
    1. Suggested Reading -
      - a. <http://www.topcoder.com/tc?module=Static&d1=tutorials&d2=primalityTesting>
      - b. Cormen 31.8
      - c. 2.2 from Number Theory by SY Yan
    2. Problems -
      - a. PON, PRIC, SOLSTRAS on SPOJ
      - b. [http://www.topcoder.com/stat?c=problem\\_statement&pm=4515](http://www.topcoder.com/stat?c=problem_statement&pm=4515)
- e. Prime generation techniques - Sieve of Eratosthenes
  - Suggested Problems - PRIME1 on SPOJ
- f. GCD using euclidean method
  - Suggested Reading
    1. 31.2 Cormen
  - Problems -

1. GCD on SPOJ
2. <http://uva.onlinejudge.org/external/114/11424.html>
- g. Logarithmic Exponentiation
  - Suggested Reading -
    1. <http://www.topcoder.com/tc?module=Static&dl=tutorials&d2=primalityTesting>
- h. Integer Factorization
  - Naive  $O(\sqrt{n})$  method
  - Pollard Rho factorization
  - Suggested Reading
    1. 2.3 from Number Theory SY Yan
    2. 31.9 Cormen
  - Problems -
    1. [http://www.topcoder.com/stat?c=problem\\_statement&pm=2986&rd=5862](http://www.topcoder.com/stat?c=problem_statement&pm=2986&rd=5862)
    2. <http://www.spoj.pl/problems/DIVSUM2/>
    3. [http://www.topcoder.com/stat?c=problem\\_statement&pm=4481&rd=6538](http://www.topcoder.com/stat?c=problem_statement&pm=4481&rd=6538)
- i. Stirling numbers
- j. Wilson theorem
  - $nCr \% p$  in  $O(p)$  preprocess and  $O(\log n)$  query
- k. Lucas Theorem
- l. Suggested Reading for Number Theory -
  - Number theory for computing by Song Y Yan [ Simple book describing concepts in details ]
  - Concepts are also superficially covered in Chapter 31 of Introduction to Algorithms by Cormen
  - <http://www.codechef.com/wiki/tutorial-number-theory>
  - [http://www.algorithmist.com/index.php/Category:Number\\_Theory](http://www.algorithmist.com/index.php/Category:Number_Theory)
- m. Problems on Number Theory -
  - [http://www.algorithmist.com/index.php/Category:Number\\_Theory](http://www.algorithmist.com/index.php/Category:Number_Theory)
  - <http://problemclassifier.appspot.com/index.jsp?search=number&usr=>

**Till 6th june.**

## **8. Math (Probability, Counting, Game Theory, Group Theory, Generating functions, Permutation Cycles, Linear Algebra)**

### **a. Probability.**

#### Syllabus

- Basic probability and Conditional probability
  1. Suggested problems
    - a. <http://www.spoj.pl/problems/CT16E/>
    - b. <http://www.spoj.pl/problems/CHICAGO/>
- Random variables, probability generating functions
- Mathematical expectation + Linearity of expectation
  1. Suggested problems
    - a. <http://www.spoj.pl/problems/FAVDICE/>
    - b. [http://www.topcoder.com/stat?c=problem\\_statement&pm=10744](http://www.topcoder.com/stat?c=problem_statement&pm=10744)
- Special discrete and continuous probability distributions
  1. Bernoulli, Binomial, Poisson, normal distribution
  2. Suggested Problem
    - a. <http://acm.sgu.ru/problem.php?contest=0&problem=498>
- Suggested Readings
  1. Cormen appendix C (very basic)
  2. Topcoder probability tutorial
 <http://www.topcoder.com/tc?module=Static&dl=tutorials&d2=probabilities>
  3. [http://en.wikipedia.org/wiki/Random\\_variable](http://en.wikipedia.org/wiki/Random_variable)
  4. [http://en.wikipedia.org/wiki/Expected\\_value](http://en.wikipedia.org/wiki/Expected_value)
  5. William Feller, An introduction to probability theory and its applications

### **b. Counting**

#### Syllabus

- Basic principles - Pigeon hole principle, addition, multiplication rules
  1. Suggested problems
    - a. <http://acm.timus.ru/problem.aspx?space=1&num=1690>
    - b. [http://www.topcoder.com/stat?c=problem\\_statement&pm=10805](http://www.topcoder.com/stat?c=problem_statement&pm=10805)
  3. Suggested readings
    - a. [http://en.wikipedia.org/wiki/Combinatorial\\_principles](http://en.wikipedia.org/wiki/Combinatorial_principles)
    - b. <http://www.topcoder.com/tc?module=Static&dl=tutorials&d2=combinatorics>
    - c. <http://www.maa.org/editorial/knot/pigeonhole.html>
- Inclusion-exclusion
  1. Suggested readings
    - a. [http://en.wikipedia.org/wiki/Inclusion-exclusion\\_principle](http://en.wikipedia.org/wiki/Inclusion-exclusion_principle)
  2. Suggested problems
    - a. [http://www.topcoder.com/stat?c=problem\\_statement&pm=4463&rd=6536](http://www.topcoder.com/stat?c=problem_statement&pm=4463&rd=6536)
    - b. [http://www.topcoder.com/stat?c=problem\\_statement&pm=10238](http://www.topcoder.com/stat?c=problem_statement&pm=10238)
- Special numbers
  1. Suggested reading - Stirling, eulerian, harmonic, bernoulli, fibonacci numbers
    - a. [http://en.wikipedia.org/wiki/Stirling\\_number](http://en.wikipedia.org/wiki/Stirling_number)

- b. [http://en.wikipedia.org/wiki/Eulerian\\_numbers](http://en.wikipedia.org/wiki/Eulerian_numbers)
  - c. [http://en.wikipedia.org/wiki/Harmonic\\_series\\_\(mathematics\)](http://en.wikipedia.org/wiki/Harmonic_series_(mathematics))
  - d. [http://en.wikipedia.org/wiki/Bernoulli\\_number](http://en.wikipedia.org/wiki/Bernoulli_number)
  - e. [http://en.wikipedia.org/wiki/Fibonacci\\_numbers](http://en.wikipedia.org/wiki/Fibonacci_numbers)
  - f. Concrete mathematics by Knuth
- 2. Suggested problems
  - a. [http://www.topcoder.com/stat?c=problem\\_statement&pm=1643](http://www.topcoder.com/stat?c=problem_statement&pm=1643)
  - b. [http://www.topcoder.com/stat?c=problem\\_statement&pm=8202&rd=11125](http://www.topcoder.com/stat?c=problem_statement&pm=8202&rd=11125)
  - c. [http://www.topcoder.com/stat?c=problem\\_statement&pm=8725](http://www.topcoder.com/stat?c=problem_statement&pm=8725)
  - d. [http://www.topcoder.com/stat?c=problem\\_statement&pm=2292&rd=10709](http://www.topcoder.com/stat?c=problem_statement&pm=2292&rd=10709)
- Advanced counting techniques - Polya counting, burnsides lemma
  - 1. Suggested reading
    - a. [http://en.wikipedia.org/wiki/Burnside's\\_lemma](http://en.wikipedia.org/wiki/Burnside's_lemma)
    - b. <http://petr-mitrichev.blogspot.com/2008/11/burnsides-lemma.html>
  - 2. Suggested Problems
    - a. [http://www.topcoder.com/stat?c=problem\\_statement&pm=9975](http://www.topcoder.com/stat?c=problem_statement&pm=9975)
    - b. <http://www.spoj.pl/problems/TRANSP/>
- c. Game theory
  - Syllabus
    - Basic principles and Nim game
      - 1. Sprague grundy theorem, grundy numbers
      - 2. Suggested readings
        - a. [http://en.wikipedia.org/wiki/Sprague%E2%80%93Grundy\\_theorem](http://en.wikipedia.org/wiki/Sprague%E2%80%93Grundy_theorem)
        - b. <http://www.topcoder.com/tc?module=Static&d1=tutorials&d2=algorithmGames>
        - c. <http://www.ams.org/samplings/feature-column/fcarc-games1>
        - d. <http://www.codechef.com/wiki/tutorial-game-theory>
      - 3. Suggested problems
        - a. [http://www.topcoder.com/stat?c=problem\\_statement&pm=3491&rd=6517](http://www.topcoder.com/stat?c=problem_statement&pm=3491&rd=6517)
        - b. [http://www.topcoder.com/stat?c=problem\\_statement&pm=3491&rd=6517](http://www.topcoder.com/stat?c=problem_statement&pm=3491&rd=6517)
    - Hackenbush
      - 1. Suggested readings
        - a. <http://en.wikipedia.org/wiki/Hackenbush>
        - b. <http://www.ams.org/samplings/feature-column/fcarc-partizan1>
      - 2. Suggested problems
        - a. <http://www.cs.caltech.edu/ipsc/problems/g.html>
        - b. <http://www.spoj.pl/problems/PT07A/>
- d. **Linear Algebra**
  - Syllabus
    - Matrix Operations
      - 1. Addition and subtraction of matrices
        - a. Suggested Reading
          - i. Cormen 28.1
      - 2. Multiplication ( Strassen's algorithm ), logarithmic exponentiation
        - a. Suggested reading
          - i. Cormen 28.2
          - ii. Linear Algebra by Kenneth Hoffman Section 1.6
        - b. Problems
          - i. <http://uva.onlinejudge.org/external/111/11149.html>
      - 3. Matrix transformations [ Transpose, Rotation of Matrix, Representing Linear transformations using matrix ]
        - a. Suggested Reading
          - i. Linear Algebra By Kenneth Hoffman Section 3.1,3.2,3.4,3.7
        - b. Problems
          - i. [http://www.topcoder.com/stat?c=problem\\_statement&pm=6877](http://www.topcoder.com/stat?c=problem_statement&pm=6877)
          - ii. JPIX on Spoj
      - 4. Determinant , Rank and Inverse of Matrix [ Gaussian Elimination , Gauss Jordan Elimination]
        - a. Suggested Reading
          - i. 28.4 Cormen
          - ii. Linear Algebra by Kenneth Chapter 1
        - b. Problems
          - i. [http://www.topcoder.com/stat?c=problem\\_statement&pm=8174](http://www.topcoder.com/stat?c=problem_statement&pm=8174)
          - ii. [http://www.topcoder.com/stat?c=problem\\_statement&pm=6407&rd=9986](http://www.topcoder.com/stat?c=problem_statement&pm=6407&rd=9986)
          - iii. [http://www.topcoder.com/stat?c=problem\\_statement&pm=8587](http://www.topcoder.com/stat?c=problem_statement&pm=8587)
          - iv. HIGH on Spoj



5. Solving system of linear equations
  - a. Suggested Reading
    - i. 28.3 Cormen
    - ii. Linear Algebra by Kenneth Chapter 1
  - b. Problems -
    - i. [http://www.topcoder.com/stat?c=problem\\_statement&pm=3942&rd=6520](http://www.topcoder.com/stat?c=problem_statement&pm=3942&rd=6520)
6. Using matrix exponentiation to solve recurrences
  - a. Suggested Reading
    - i. <http://www.topcoder.com/tc?module=Static&d1=features&d2=010408>
  - b. Problems
    - i. REC, RABBIT1 , PLHOP on spoj
    - ii. [http://www.topcoder.com/stat?c=problem\\_statement&pm=6386](http://www.topcoder.com/stat?c=problem_statement&pm=6386) ,  
[http://www.topcoder.com/stat?c=problem\\_statement&pm=7262](http://www.topcoder.com/stat?c=problem_statement&pm=7262),  
[http://www.topcoder.com/stat?c=problem\\_statement&pm=6877](http://www.topcoder.com/stat?c=problem_statement&pm=6877)
7. Eigenvalues and Eigen-vectors
  - a. Problems
    - i. [http://www.topcoder.com/stat?c=problem\\_statement&pm=2423&rd=4780](http://www.topcoder.com/stat?c=problem_statement&pm=2423&rd=4780)
- Polynomials
  1. Roots of a polynomial [ Prime factorization of a polynomial, Integer roots of a polynomial, All real roots of a polynomial ]
    - a. Problems
      - i. [http://www.topcoder.com/stat?c=problem\\_statement&pm=8273&rd=10798](http://www.topcoder.com/stat?c=problem_statement&pm=8273&rd=10798)
      - ii. POLYEQ , ROOTCIPH on Spoj
  2. Lagrange Interpolation
    - a. Problems
      - i. [http://www.topcoder.com/stat?c=problem\\_statement&pm=10239](http://www.topcoder.com/stat?c=problem_statement&pm=10239)
      - ii. [http://www.topcoder.com/stat?c=problem\\_statement&pm=8725](http://www.topcoder.com/stat?c=problem_statement&pm=8725)
- e. Permutation cycles
  - Suggested Reading
    1. Art of Computer Programming by Knuth Vol. 3
  - Problems
    1. ShuffleMethod, Permutation and WordGame on topcoder.
- f. Group Theory
  - Burnside Lemma, Polya's theorem
    1. Suggested Reading
      - a. Hernstein's topics in algebra
      - b. <http://petr-mitrichev.blogspot.com/2008/11/burnsides-lemma.html>
    2. Problems
      - a. TRANSP on spoj
      - b. [http://www.topcoder.com/stat?c=problem\\_statement&pm=9975](http://www.topcoder.com/stat?c=problem_statement&pm=9975)
- b. Generating functions
  - Suggested Reading
    1. Herbert Wilf's generating functionology/
    2. Robert Sedgewick and Flajolet's Combinatorial analysis

## 9. Data Structures.

### i. Basic

- a. Arrays/Stacks/Queues :
  - Problems
    1. <https://www.spoj.pl/problems/STPAR/>
    2. <https://www.spoj.pl/problems/SHOP/>
    3. <https://www.spoj.pl/problems/WATER/>
  - Reading:
    1. CLRS: section 10.1
    2. <http://www.topcoder.com/tc?module=Static&d1=tutorials&d2=dataStructures>
- b. Singly/Doubly Linked List :
  - Problems
    1. <https://www.spoj.pl/problems/POSTERS/>
  - Reading: CLRS: section 10.2, Mark Allen Weiss Chapter 3
- c. Hash Tables :
  - Problems
    1. <https://www.spoj.pl/problems/HASHIT/>
    2. <https://www.spoj.pl/problems/CUCKOO/>
  - Reading: CLRS: Chapter 11, Mark Allen Weiss Chapter 5
- d. Circular linked list / queue
  - Problems
    1. <https://www.spoj.pl/problems/CTRICK/>

- e. Binary/nary Trees
    - Reading
      1. CLRS: section 10.4
      2. CLRS: Chapter 12
      3. Mark Allen Weiss Chapter 4
      4. <http://www.topcoder.com/tc?module=Static&dl=tutorials&d2=binarySearchRedBlack>
  - f. Heaps
    - Problems
      1. <https://www.spoj.pl/problems/PRO/>
      2. <https://www.spoj.pl/problems/EXPEDI/>
    - Reading : Mark Allen Weiss Chapter 6
  - ii. Advanced**
    - a. Trie (Keyword tree)
      - Problems
        1. <https://www.spoj.pl/problems/MORSE/>
        2. <https://www.spoj.pl/problems/EMOTICON/>
      - Reading
    - b. Interval trees / Segment Trees
      - Problems
        1. <https://www.spoj.pl/problems/ORDERS/>
        2. <https://www.spoj.pl/problems/FREQUENT/>
      - Reading
    - c. Fenwick (Binary Indexed) trees
      - Problems
        1. <https://www.spoj.pl/problems/MATSUM/>
      - Reading: <http://www.topcoder.com/tc?module=Static&dl=tutorials&d2=binaryIndexedTrees>
    - d. Disjoint data structures
      - Problems
        1. <https://www.spoj.pl/problems/BLINNET/>
        2. <https://www.spoj.pl/problems/CHAIN/>
      - Reading:
        1. <http://www.topcoder.com/tc?module=Static&dl=tutorials&d2=disjointDataStructure>
        2. Mark Allen Weiss Chapter 8
    - e. Range minimum Query (RMQ)
      - Problems
        1. <https://www.spoj.pl/problems/GSS1/>
      - Reading
 <http://www.topcoder.com/tc?module=Static&dl=tutorials&d2=lowestCommonAncestor>
    - f. Customized interval/segment trees (Augmented DS)
      - Problems
        1. <https://www.spoj.pl/problems/GSS3/>
        2. <https://www.spoj.pl/problems/RRSCHED/>
      - Reading: CLRS: Chapter 14 (augmented DS)
    - g. AVL Trees
      - Problems
        1. <https://www.spoj.pl/problems/ORDERS/>
      - Reading
  - iii. Miscellaneous (Not to be covered)**
    - a. Splay Trees
    - b. B/B+ Trees
    - c. k-d Trees
    - d. Red-black Trees
    - e. Skip List
    - f. Binomial/Fibonacci heaps
  - iv. Exercises**
    1. <https://www.spoj.pl/problems/LAZYPROG/> (Hint: Heaps)t
    2. <https://www.spoj.pl/problems/HELPR2D2/> (Hint: Interval Trees)
    3. <https://www.spoj.pl/problems/SAM/> (Hint: Heaps)
    4. <https://www.spoj.pl/problems/PRHYME/> (Hint: Trie)
    5. <https://www.spoj.pl/problems/HEAPULM/> (Hint: Interval Trees)
    6. <https://www.spoj.pl/problems/CORNET/> (Hint: Disjoint )
    7. <https://www.spoj.pl/problems/EXPAND/>
    8. <https://www.spoj.pl/problems/WPUZZLES/>
    9. <https://www.spoj.pl/problems/LIS2/>
10. **Search Techniques/Bruteforce writing techniques/Randomized algorithms.**
- a. Backtracking - [Beginner].
    - problems ->
      1. N queens problems
      2. Knight's Tour
      3. Sudoku Problem
      4. Tiling Problem.

5. 15 puzzle.
- b. Dancing Links and Algorithm X given by Knuth - [Advanced]
- problems - PRLGAME, SUDOKU, NQUEEN on SPOJ
  - Suggested reading -
    1. <http://www-cs-faculty.stanford.edu/~uno/papers/dancing-color.ps.gz>
- c. Binary Search - [Beginner].
- problems - AGGRCOW on SPOJ. Refer the tutorial for more problems.
  - finding all real roots of a polynomial using binary search. [intermediate].
  - Suggested Reading -
    1. <http://www.topcoder.com/tc?module=Static&dl=tutorials&d2=binarySearch>
- d. Ternary Search - [Intermediate].
- problems -
    1. <http://www.spoj.pl/problems/KPPOLY/>
    2. <http://www.codechef.com/DEC09/problems/K1/>
    3. [http://www.topcoder.com/stat?c=problem\\_statement&pm=4705&rd=7993](http://www.topcoder.com/stat?c=problem_statement&pm=4705&rd=7993)
    4. [http://www.topcoder.com/stat?c=problem\\_statement&pm=7741&rd=10671](http://www.topcoder.com/stat?c=problem_statement&pm=7741&rd=10671)
    5. [http://www.topcoder.com/stat?c=problem\\_statement&pm=6464&rd=9994](http://www.topcoder.com/stat?c=problem_statement&pm=6464&rd=9994)
    6. [http://www.topcoder.com/stat?c=problem\\_statement&pm=3501&rd=6529](http://www.topcoder.com/stat?c=problem_statement&pm=3501&rd=6529)
    7. [http://www.topcoder.com/stat?c=problem\\_statement&pm=4567&rd=6539](http://www.topcoder.com/stat?c=problem_statement&pm=4567&rd=6539)
- e. Meet in the middle [Intermediate].
- problems -
    1. <http://www.spoj.pl/problems/MAXISET/>
    2. Hill Climbing [Advanced].
- f. Regular Iteration to reach a fixed point [Advanced].
- Newton-Raphson method to find root of a mathematical function.
  - Iterations to solve linear non homogeneous system of equations.
- General programming issues in contests ->**
- g. Arithmetic Precision - [Beginner].
- Suggested Reading -
    1. <http://www.topcoder.com/tc?module=Static&dl=tutorials&d2=integersReals>
- h. Representing sets with bitmasks and manipulating bitmasks - [Beginner].
- Suggested Reading -
    1. <http://www.topcoder.com/tc?module=Static&dl=tutorials&d2=bitManipulation>
  - problems - refer to the tutorial link in Suggested reading section.