List of Mathematics Topics for programming Competitions -

1. **Basic Geometry/Euclidean Geometry/Coordinate Geometry/ [3-D variants of everything].**
2. ***Computational Geometry.***
   - **a. Graham Scan algorithm for Convex Hull O(n * log(n)).**
   - **b. Online construction of 3-D convex hull in O(n^2).**
   - **c. Bentley Ottmann algorithm to list all intersection points of n line segments in O((n + I) * logn).**
     - Suggested Reading -
       1. http://softsurfer.com/Archive/algorithm_0108/algorithm_0108.htm
   - **d. 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.
   - **e. 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&d1=tutorials&d2=lineSweep
     - Problems - Follow the tutorial for list of problems.
   - **f. Area of Union of Circles.**
   - **g. Delayunay Triangulation of n points in O(n * logn).**
   - **h. Voronoi Diagrams of n points in O(n * logn) using Fortunes algorithm.**
   - **i. Point in a polygon problem -**
     - O(n) solution without preprocessing.
     - O(logn) algorithm with O(n * logn) preprocessing for convex polygons.
   - **j. Problems on computational geometry -**
     - BSHEEP, BULK, SEGVIS, CONDUIT, RUNAWAY, DIRVS, RAIN1, SHAMAN, TCUTTER, LITEPIPE, RHOMBS, FSHEEP, FLBRKLIN, CERC07P, BAC, ALTARS, CERC07C, NECKLACE, CH3D, RECTANGL, POLYSSQ, FOREST2, KPPOLY, RAIN2, SEGMENTS, ARCHPLG, BALLOON, CIRCLES, COMPASS, EOWAMRT, ICERINK on SPOJ.
     - CultureGrowth, PolygonCover on Topcoder.
   - **k. Suggested Reading -**
     - Computational Geometry: Algorithms and applications. Mark De Burg.
2. ***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
     - 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
       5. http://www.topcoder.com/stat?c=problem_statement&pm=2342
   - **b. Fermat's theorem, Euler 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
   - **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
   - **e. Prime generation techniques - Sieve of Erastothenes**
     - 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&d1=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
       2. http://www.spoj.pl/problems/DIVSUM2/
       3. 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
m. **Problems on Number Theory -**
   - http://www.algorithmist.com/index.php/Category:Number_Theory
   - http://problemclassifier.appspot.com/index.jsp?search=number&usr=

4. **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
      - **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 probabilty tutorial
           http://www.topcoder.com/tc?module=Static&d1=tutorials&d2=probabilities
        3. http://en.wikipedia.org/wiki/Random_variable
        4. 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
        3. Suggested readings
           a. http://en.wikipedia.org/wiki/Combinatorial_principles
           b. http://www.topcoder.com/tc?module=Static&d1=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
        2. Suggested problems
           a. http://www.topcoder.com/stat?c=problem_statement&pm=4463&rd=6536
           b. http://www.topcoder.com/stat?c=problem_statement&pm=10238
      - **Special numbers**
        1. Suggested reading - Stirling, eurlerian, harmonic, bernoulli, fibonnacci numbers
           a. http://en.wikipedia.org/wiki/Stirling_number
           b. http://en.wikipedia.org/wiki/Eulerian_numbers
           c. http://en.wikipedia.org/wiki/Harmonic_series_(mathematics)
           d. http://en.wikipedia.org/wiki/Bernoulli_number
           e. http://en.wikipedia.org/wiki/Fibonnaci_numbers
           f. Concrete mathematics by Knuth
        2. Suggested problems
           a. http://www.topcoder.com/stat?c=problem_statement&pm=1643
           b. http://www.topcoder.com/stat?c=problem_statement&pm=8202&rd=11125
           c. http://www.topcoder.com/stat?c=problem_statement&pm=8725
           d. 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
           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
           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
           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
           b. 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
        ii.JPIX on Spoj
  4. **Determinant , Rank and Inverse of Matrix [Gaussean 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
        ii.http://www.topcoder.com/stat?c=problem_statement&pm=6407&rd=9986
        iii. 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
  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=7262, http://www.topcoder.com/stat?c=problem_statement&pm=6877
  7. **Eigen values and Eigen vectors**
     a. Problems
        i. 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
        ii.POLYEQ , ROOTCIPH on Spoj
  2. **Lagrange Interpolation**
     a. Problems
        i. http://www.topcoder.com/stat?c=problem_statement&pm=10239
        ii.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

- **Bernside Lemma, Polias 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

b. Generating functions

- Suggested Reading
  1. Herbert Wilf's generating functionology
  2. Robert Sedgewick and Flajoulet's Combinatorial analysis

Resource https://docs.google.com/document/d/1_dc3Ifq7Gq1LxhiqMMmE9UbTsXpdRiYh4pKILYG2eA4/edit