Oral Qualifying Exam Syllabus
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Proposed Committee: Professors Kopparty(chair), Kahn, Saks, Saraf

1. **Combinatorics**
    a. *Basic Enumeration:* Counting arguments, generating functions, binomial coefficients, recurrence relations, inclusion-exclusion, Stirling's formula
    b. *Set Systems:* Sperner's Theorem, LYM Inequality, Erdos-Ko-Rado, Kruskal Katona, Dilworth's Theorem, Fisher's Inequality, Raychaudhuri-Wilson, Frankl-Wilson
    c. *Lattices:* Wiesner's Thoerem, Distributive and Geometric Lattices, 1/3-2/3 Conjecture, Mobius Inversion
    d. *Ramsey Theory:* Ramsey's Theorem, Probabilistic Lower Bounds, Schur's Theorem, van-der Waarden
    e. *Correlation Inequalities:* Ahlswede-Daykin, FKG Inequality, Harris
    f. *Discrepancy:* Beck-Fiala Theorem
    g. *Polynomial Methods:* Cauchy-Davenport, Combinatorial Nullstellansatz, Kemnitz Conjecture
2. **Graph Theory**
    a. *Matching:* Hall's Theorem, Konig's Theorem, stable matchings, Tutte's Theorem
    b. *Connectivity:* Menger's Theorem, Max Flow-Min Cut,
    c. *Extremal Problems:* Turan's Theorem, Erdos-Stone, Szemeredi's Regularity Lemma
    d. *Coloring:* Vizing's Theorem, Brook's Theorem, 5 Color Theorem
    e. *Planarity:* Kuratowski's Theorem, Crossing Number
3. **Probabilistic Methods**
    a. *Basics:* Markov, Chebyshev, Chernoff Bounds, Linearity of Expectation, alterations, Azuma's inequality
    b. *Second Moment Method*: application to threshold functions containing a fixed graph
    c. *Local Lemma*: Symmetric and General Versions, Application to Ramsey Lower Bounds
    d. *Poisson Paradigm*: Janson Inequalities, Brun's Sieve

4. **Computational Complexity**
    a. P v. NP: Definitions, reducibility, the Cook-Levin Theorem, NP completeness of SAT, independent set, 0/1 integer programming, and directed hamiltonian path, conditions that imply P≠NP
    b. Diagonalization: Ladner's Theorem, Oracle Turing Machines and the Baker-Gill-Solovay Theorem
    c. Space-bounded complexity: definitions, PSPACE completeness of TQBF, NL completeness of PATH, Savitch's theorem, the Immerman-Szeleplcsenyi Theorem
    d. Separation theorems: Time and Space Hierarchy Theorems (deterministic and nondeterministic versions)

e. Polynomial hierarchy: Definitions of Σ_i, Π_i, complete problems, conditionsthat lead to the collapse of PH.
f. Circuits: P P/poly, CKT-SAT and alternate proof of Cook-Levin, Characterization of $\subseteq$
g. P/poly as TMs with advice, Karp-Lipton Theorem, Meyer's Theorem, existence of hard functions, Nonuniform Hierarchy Theorem, definitions of NC_i, AC_i
h. Randomization: Definitions of RP, BPP and ZPP, error reduction, Sipser-Gacs Theorem, BPP P/poly, randomized reductions and definition of BP $\subseteq$ •NP
i. Interactive Proofs: definitions, dIP=NP, GNI AM, NP completeness of GI implies $\Sigma_2 = \in \Pi_2$, IP=PSPACE
j. PCP theorem: definitions, equivalence of the 3 versions, hardness of approximation for vertex cover and independent set.