1. Combinatorial Design
   a. Existence and Construction of
   i. Balanced Incomplete Block Design
   ii. Steiner Triple System (k = 3)
      1. If lambda = 1, then v congruent 1 or 3 mod 6 if and only if there exist a triple system
   iii. Kirkman triple system
      1. Steiner but the 3-block need to be partitioned into classes, each of which contains n/3 3-block, and each treatment appear once in the class.
      2. There is a Kirkman triple system on v treatments for all v congruent 3 mod 6.
   iv. Latin squares
   v. One factorisation
2. Geometry
   a. Fermat-Toricelli Point, smallest total distance to vertices if all angle less than or equal to 120 degree. Otherwise it's the vertex with angle more than 120 degree.
   b. Smallest-length pedal triangle -> Orthic triangle, pedal triangle with smallest perimeter.
3. Group Theory
   a. jika phi: G -> H group homomorphism, maka image(phi) isomorphic G / ker(phi)
4. Counting techniques
   a. Twelvefold way
   i. Catat tabel
   ii. $\{n, x\}$ is Stirling number of second kind

iii. $p\_x(n)$ is partition of n into x parts.

The generating function for p(n) is given by[5]

$$\sum_{n=0}^{\infty} p(n)x^n = \prod_{k=1}^{\infty} \left(\frac{1}{1-x^k} \right).$$

iv.

The twelve combinatorial objects and their enumeration formulas.

f-class	Any f	Injective f	Surjective f
f	n-sequence in X x^n	n-permutation of X $x^{\underline{n}}$	composition of N with x subsets $x!\{\begin{smallmatrix}n\\x\end{smallmatrix}\}$
$f \cdot S_n$	n-multiset of X $\binom{x+n-1}{n}$	n-subset of X $\binom{x}{n}$	composition of n with x terms $\binom{n-1}{n-x}$
$S_x \cdot f$	partition of N into ≤ x subsets $\sum_{k=0}^{x}\{\begin{smallmatrix}n\\k\end{smallmatrix}\}$	partition of N into ≤ x elements $[n \le x]$	partition of N into x subsets $\{\begin{smallmatrix}n\\x\end{smallmatrix}\}$
$S_x \cdot f \cdot S_n$	partition of n into ≤ x parts $p_x(n+x)$	partition of n into ≤ x parts 1 $[n \le x]$	partition of n into x parts $p_x(n)$

   b. General Recursion
   c. GF and Exponential GF
5. Topological combinatorics
   a. Sperner Lemma
   i. 2D: Given a triangle ABC, and a triangulation T of the triangle, the set S of vertices of T is colored with three colors in such a way that: (i) A, B, C are colored 1, 2, 3 respectively. Each vertex on an edge of ABC is to be colored only with one of the two colors of the ends of its edge. Result: There exists a triangle T, whose vertices are colored with the three different colors.
   ii. Multidimensional: Given n-dimnesional simplex, triangulate to smaller n-dimensional simplex. (i) Vertices of the original simplex are colored with differnent colors. (ii) Vertices of T located on any k-dimensional subface of the large simplex are colored only with the colors in the vertices of the original simplex that is part of the k-dimensional subface. Result -> There exists odd number of simplices from T whose vertices are colored with all n+1 colors.

   b. Necklace Splitting Theorem
   i. Discrete splitting: The necklace has kn beads. The beads come in t diferent colors. There are k * a_i beads of each color i, where a_i is positive integer. Partition the necklace into k parts, each of which has exactly a_i beads of color i. Use at most (k-1)t cuts.
   6. Helly Theorem
   a. Let X_1, X_2, …, X_n be a finite collection of convex subsets of R^d with n>d. If the intersection of every d+1 of these sets is nonempty, then the whole collection has a nonempty intersection

	$f(n)$	$a_n^{(p)}$
	Exponential function	
(i)	Ak^n	Bk^n
	k is not a characteristic root	
(ii)	Ak^n	$Bn^m k^n$
	k is a characteristic root of multiplicity m	
	Polynomial	
(i)	$\sum_{i=0}^{t} p_i n^i$	$\sum_{i=0}^{t} q_i n^i$
	1 is not a characteristic root	
(ii)	$\sum_{i=0}^{t} p_i n^i$	$n^m \sum_{i=0}^{t} q_i n^i$
	1 is a characteristic root of multiplicity m	
	Special combined function	
(i)	$An^t k^n$	$\left(\sum_{i=0}^{t} q_i n^i\right) k^n$
	k is not a characteristic root	
(ii)	$An^t k^n$	$n^m \left(\sum_{i=0}^{t} q_i n^i\right) k^n$
	k is a characteristic root of multiplicity m	