* Langrange's theorem - Every positive integer can be represented as a sum of four squares.
* Zeckendorf's theorem - states that every positive integer has a unique representation as a sum of fibonacci numbers.
* Wilson's Theorem - state that a number n is prime when.
  $(n-1)! \bmod n = n-1$

* Fermat's theorem - $x^{m-1} \bmod m = 1$ {m is prime and x and m are coprime}
  general form - $x^k \bmod m = x^{k \bmod (m-1)} \bmod m$.

* Modular Inverse - $x x^{-1} \bmod m = 1$ { if x and m are co-prime }.

* Combinatorics

* ${}^nC_k = {}^{n-1}C_{k-1} + {}^{n-1}C_k$ * ${}^nC_k = {}^nC_{n-k}$ * $\sum_{k=0}^{n} {}^nC_k = 2^n$

* They also appear in pascal's triangle

1
1 1
1 2 1
1 3 3 1

* Catalan Numbers (C_n) the number of valid parenthesis expression n left

$$C_n = \sum_{i=0}^{n-1} C_i C_{n-i-1} = \frac{1}{n+1} {}^{2n}C_n$$

* The number of binary trees.
* There are C_{n-1} rooted trees of n nodes.

* Inclusion - Exclusion $|A \cup B| = |A| + |B| - |A \cap B|$
  It can be used to calculate the number of derangement of Elements.
  $n! - |X_1 \cup X_2 \cup \dots X_n|$ or the recursive formula

$$\begin{cases} 0 & n=1 \\ 1 & n=2 \\ (n-1)(f(n-2)+f(n-1)) & n>2 \end{cases}$$

* Burnside's lemma.
  Can be used to count the number of combinations so that only one representative is counted for each group of symmetric combination

$$\sum_{k=1}^{n} \frac{c(k)}{n}$$

* $$\sum_{i=0}^{n-1} \frac{m^{\gcd(i,n)}}{n}.$$

* Cayley's formula - there n^{n-2} labelled trees that contain n nodes.
  The nodes