1. For a polynomial $P(x) = ax^3 + bx^2 + cx + d$
   $\alpha + \beta + \gamma = -b/a$
   $\alpha * \beta * \gamma = c/a$
   where α, β, γ are the roots of the polynomial.
2. For a polynomial $P(x) = ax^2 + bx + c$
   $\alpha = \frac{b-\sqrt{b^2-4*a*c}}{2*a}$
   $\beta = \frac{-b-\sqrt{b^2-4*a*c}}{2*a}$
   where α, β are the roots of the polynomial.
3. $1^3 + 2^3 + 3^3 + \ldots + n^3 = [\frac{n*(n+1)}{2}]^2$
4. $1^2 + 2^2 + 3^2 + \ldots + n^2 = \frac{n*(n+1)*(2n+1)}{6}$
5. For a arithmetic progression
   $a, a+d, a+2d, a+3d\ldots$
   $T(n) = a + (n-1) * d$
   $S(n) = \frac{n}{2}[2a + (n-1)d]$

6)For a geometric progression
$a, ar, ar^2, ar^3\ldots$
$S(n) = a(\frac{r^n-1}{r-1})$
$S(\infty) = \frac{a}{1-r}$ where $[-1 < r < 1]$

7)Bertland Ballot's Theorem problem -
"In an election where candidate a receives p votes and b receives q votes with p>q, what is the probability that a will be strictly ahead of b throughout the count"
Ans - $\frac{p-q}{p+q}$
And if ties are allowed then
Ans - $\frac{p-q+1}{p+1}$

8. $(\frac{A}{B})\%mod = (A\%mod * x\%mod)\%mod$
   where x is the modular multiplicative inverse of B under mod

9)Fermat's little theorem
$a^{m-2} \equiv a^{-1}\ \%mod$
when mod is prime
10) $E_p(n!)$: Exponent of p in $n!$ where p is a prime
$E_p(n!) = \lfloor\frac{n}{p}\rfloor + \lfloor\frac{n}{p^2}\rfloor + \lfloor\frac{n}{p^3}\rfloor + \lfloor\frac{n}{p^4}\rfloor + \ldots$

11. let N be a natural number
    $N = p_1^{\alpha^1} * p_2^{\alpha^2} * p_3^{\alpha^3}\ldots$
    Then total number of divisors =
    $(\alpha_1 + 1) * (\alpha_2 + 1) * (\alpha_3 + 1) * \ldots$
    Sum of divisors = $(\frac{p_1^{\alpha_1+1}-1}{p_1-1}) * (\frac{p_2^{\alpha_2+1}-1}{p_2-1}) * (\frac{p_3^{\alpha_3+1}-1}{p_3-1})\ldots$
    Product of divisors = $n^{\frac{(\alpha_1+1)(\alpha_2+1)\times\cdots\times(\alpha_m+1)}{2}}$
    If n is perfect square then multiply it by $\sqrt{x}$ in case of product of divisor
12. $a^b\%mod = a^{b\%(mod-1)}\%mod$ when mod is prime
13. $a^b\%mod = a^{b\%\phi(mod)}\%mod$ when mod is not prime
    where $\phi(mod)$ = Euler totient function of mod
14. Derangement of N elements
    $D_n = n!(1 - \frac{1}{1!} + -\frac{1}{2!} + (-1)^n\frac{1}{n!})$

15. If m and n are two co-prime numbers then the biggest number which can not be represented as $(am + bn)$ for non negative integer m and n is $mn - m - n$
16. Euler Totient function $(\phi(n))$:Number of numbers which are coprime with n in range of $[1, n]$

$\phi(n) = n(1 - \frac{1}{p_1})(1 - \frac{1}{p_2})(1 - \frac{1}{p_3})$
where $n = p_1^{\alpha^1} * p_2^{\alpha^2} * p_3^{\alpha^3} \ldots$

15. Centroid of a triangle $(\frac{x_1+x_2+x_3}{3}, \frac{y_1+y_2+y_3}{3})$
16. Incentre $(\frac{ax_1+bx_2+cx_3}{a+b+c}, \frac{ay_1+by_2+cy_3}{a+b+c})$
17. Area of triangle $\frac{1}{2}[x_1 * (y_2 - y_3) + x_2 * (y_3 - y_1) + x_3 * (y_1 - y_2)]$
18. Angle between two lines $\tan\theta = |\frac{m_1 - m_2}{1+m_1*m_2}|$
19. Distance of a point from a line
    $|\frac{ax_1+by_1+c}{\sqrt{a^2+b^2}}|$
20. Image of a point on a line
    $\frac{x-x_1}{a} = \frac{y-y_1}{b} = -2 * \frac{ax_1+by_1+c}{a^2+b^2}$
21. Distance between parallel lines
    $\frac{|c_1-c_2|}{\sqrt{a^2+b^2}}$
22. For a simple polygon pick's theorem states that
    $A = I + \frac{B}{2} - 1$
    $A =$ Area of simple polygon
    $B =$ Number of points on its boundary
    $I =$ be the number of integer points stricIty inside the polygon

23.For a line from (a, b) to (c, d)
the number of lattice points on it is $gcd(c - a, d - b) + 1$