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Algebra 2 - REA's Quick Access Reference Chart (Quick Access Reference Charts)

PAST FACTS REVIEW
Quick Access **ALGEBRA II**

SYSTEMS OF LINEAR EQUATIONS
A. DEFINITION - A system of linear equations is a collection of equations where each equation only contains terms that are either constants or constants multiplied by a single variable.
 $3x + 2y - 4z = 5$
 $4x - 3y + z = 6$
 $-4x + 4y + z = 6$

B. MATRICES - Rewrite the coefficients of the system as an augmented matrix then perform elementary row operations until all but the rightmost column is equal to the identity matrix. The rightmost column gives you the solutions for each variable.
Augmented matrix: $\begin{bmatrix} 3 & 2 & -4 & 5 \\ 4 & -3 & 1 & 6 \\ -4 & 4 & 1 & 6 \end{bmatrix}$

C. CRAMER'S RULE - Let A be the square matrix of coefficients and let the last column of the augmented matrix. Each column represents the coefficients of one variable. Let A_i be the matrix A with the i th column replaced with the last column of the augmented matrix. Then the value of each variable is as follows:
 $x_i = \frac{\det A_i}{\det A}$, where x_i is the i th variable, and \det indicates the determinant.

D. ELIMINATION - Scale each equation so that they can be added or subtracted to eliminate variables.
 $2x + 4y = 14$ $4x + 8y = 28$
 $4x - 7y = -27$ $4x - 7y = -27$
 $11y = 45$ $y = 4.1$

E. SUBSTITUTION - Solve one equation for one of the variables then substitute that into another equation. Repeat until all variables are found.
 $2x + 4y = 14$ $2x + 4(3) = 14$ $2x + 12 = 14$ $2x = 2$ $x = 1$

QUADRATIC EQUATIONS
A. DEFINITION - An equation of the form $ax^2 + bx + c = 0$, where $a \neq 0$, and b and c are real numbers.
B. SOLVING QUADRATIC EQUATIONS - The solutions, or roots, of a quadratic equation are the values of x that satisfy the equation. A quadratic equation has two roots that may be rational, irrational, imaginary, or complex.
1. Direct Solution:
Isolate the variable and solve directly.
 $x^2 - 9 = 0$
 $x^2 = 9$
 $x = \pm 3$
2. Factoring
Express a quadratic equation as a product set equal to 0.
 $x^2 - 5x + 6 = 0$ $(x - 2)(x - 3) = 0$
By the Zero Product Property, $x = 2$ and $x = 3$ are roots of the equation.
Then write factoring:
 $x^2 - 5x + 6 = (x - 2)(x - 3)$
Constant factorization:
 $x^2 + 2ab + b^2 = (x + b)^2$ $(x + 3)^2 = x^2 + 6x + 9$
 $x^2 - 2ab + b^2 = (x - b)^2$ $(x - 3)^2 = x^2 - 6x + 9$
C. Completing the Square:
 $x^2 - 12x + 8 = 0$
 $x^2 - 12x = -8$ isolate the variables on one side.
 $x^2 - 12x + \left(\frac{-12}{2}\right)^2 = -8 + \left(\frac{-12}{2}\right)^2$ Add $\left(\frac{b}{2}\right)^2$ to both sides.

$x^2 - 12x + 36 = -8 + 36$
 $(x - 6)^2 = 28$
 $x - 6 = \pm\sqrt{28}$
 $x = 6 \pm 2\sqrt{7}$
 $x = 2\sqrt{7} + 6$
 $x = -2\sqrt{7} + 6$

QUADRATIC FORMULA - The Quadratic Formula is a general formula for finding the roots of a quadratic equation.
 $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

1. Discriminant ($b^2 - 4ac$) - the expression under the radical sign can be used to determine the types of roots a quadratic equation has. This is because the square root of a negative number is always imaginary, and if you add or subtract 0 you always get the same number.
 $b^2 - 4ac > 0$ - the equation has 2 complex roots
 $b^2 - 4ac = 0$ - the equation has 1 double root
 $b^2 - 4ac < 0$ - the equation has 2 real roots

D. SOLVING SYSTEMS OF EQUATIONS WITH QUADRATICS
1. Linear and 1 quadratic: solve the linear and substitute in quadratic.
2. Quadratic equations: eliminate a variable, solve for other variable, and substitute.
3. 2 quadratic equations, 1 homogeneous: factor and set each factor equal to zero. Substitute and solve to find appropriate solutions.
4. 2 quadratic equations of the form $ax^2 + by + c = 0$, $a \neq 0$, $b \neq 0$, and c are real numbers: Combine the two equations and solve the homogeneous equations as indicated above.
5. 2 quadratic equations, each symmetrical in x and y : substitute $u = x + y$ and $v = x - y$ and solve the resulting equations for x and y .

EQUATIONS OF HIGHER ORDER
A. METHODS TO SOLVE EQUATIONS - ORDER ≥ 3
1. Factorization:
**2. Write 3rd order equation as $x^3 + px^2 + qx + r = 0$, where $-r =$ sum of roots, $q =$ sum of products of roots taken two at a time, $-p =$ product of the roots.
3. Graphing: the roots of an equation $f(x) = 0$ are the values of x where the graph of $y = f(x)$ is zero. These values of x are called zeros of the function and correspond to the roots.
4. After factoring as much as possible: the quadratic formula and polynomial long division can also be used.**

B. THEORY OF EQUATIONS
1. Remainder Theorem: If $P(x)$ is divided by $(x - a)$, then the remainder is $P(a)$. This implies that if $P(a) = 0$, then $(x - a)$ divides evenly into $P(x)$ and a is a root of the equation $P(x) = 0$.
2. Factor Theorem: If a is a root of the equation $f(x) = 0$, then $(x - a)$ is a factor of $f(x)$.

3. Fundamental Theorem of Algebra: Every polynomial equation $f(x) = 0$ (degree > 0) has at least one root (rational, real or complex).
4. Corollary to the Fundamental Theorem of Algebra: A polynomial equation $f(x) = 0$, where $f(x)$ is of degree n , has exactly n roots (counting double roots as 2), and so on.
5. Synthetic Division: Synthetic division is a shortened way to do polynomial long division and to check if a value is a root by the Factor Theorem. Given $x^2 - 7x + 6$, divide by $x - 2$.
 $\begin{array}{r|rr} 2 & 1 & -7 & 6 \\ & & 2 & -10 \\ \hline & 1 & -5 & -4 \end{array}$
 $x^2 - 7x + 6 = (x - 2)(x - 4)$
This implies that 2 is a root of the equation $x^2 - 7x + 6 = 0$.

6. Complex Conjugates Theorem: If $a + bi$ is a root of a polynomial equation, then $a - bi$ is also a root.
7. Irrational Conjugates Theorem: If $a + \sqrt{b}$ is a root of a polynomial equation, then $a - \sqrt{b}$ is also a root.
8. Rational Root Theorem: Every rational root of the polynomial equation $a_n x^n + a_{n-1} x^{n-1} + \dots + a_1 x + a_0 = 0$ (where a_n, a_{n-1}, \dots, a_0 are integers) must be of the form $\frac{p}{q}$, where p is a factor of a_0 and q is a factor of a_n .
**9. A general polynomial of the form $f(x) = x^n + p_1 x^{n-1} + p_2 x^{n-2} + \dots + p_{n-1} x + p_n = 0$ has the following properties:
a. $\sum x_i = -p_1$ = sum of the roots
b. $\sum p_i =$ sum of the products of the roots taken two at a time
c. $\sum (-p_i) =$ sum of the products of the roots taken three at a time
d. $(-1)^n p_n =$ product of all the roots of $f(x) = 0$.**

10. Descartes' Rule of Signs: The number of positive and negative roots of a polynomial equation $f(x) = 0$ with real coefficients can be determined by examining the variation of signs.
(ex. $3x^3 - 4x^2 + 3x^2 - 8x^2 - x + 3$ has 2 variations.)
• The number of positive roots cannot exceed the number of variations in sign of $f(x)$. The difference between the number of variations and the number of positive roots is an even number.
• The number of negative roots cannot exceed the number of variations in sign of $f(-x)$. The difference between the number of variations and the number of negative roots is an even number.

QUADRATIC FUNCTIONS
A. DEFINITION - The function $f(x) = ax^2 + bx + c$, where $a \neq 0$, and b and c are real numbers, is called a quadratic function or a function of second degree in one extension.
B. GRAPHS
**1. The graph $y = ax^2 + bx + c$ is a curve known as a parabola.
2. The vertex of the parabola is the point $\left(-\frac{b}{2a}, \frac{4ac - b^2}{4a}\right)$. The parabola's line of symmetry is the line $x = -\frac{b}{2a}$.**

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