QuickStudy ACADEMIC — Pre-Calculus Equations & Answers

FUNCTIONS & THEIR GRAPHS

Definitions

- A **function** is a relation in which each element of the domain is paired with only one element of the range.
- In most cases, x is the independent variable and y or $f(x)$ is the dependent variable.
- A function can be identified using the **vertical line test**. If a vertical line passes through the graph of the function in more than one point, the graph is not a function.
- A function can be expressed by an equation in terms of x and y or with function notation: $y = 7x - 11$ or $f(x) = 7x - 11$.

Linear Functions

A function whose graph is a non-vertical line or part of a non-vertical line. There are 3 forms of linear equations: slope-intercept, point-slope, and standard form.

- **Slope-intercept form:** $y = mx + b$, where m is the slope and b is the y-intercept of the line.
  - **EX:** If a line has a slope of 3 and y-intercept of 5, the equation is $y = 3x + 5$.
- **Point-slope form:** $y - y_1 = m(x - x_1)$, where m is the slope and (x_1, y_1) is a point on the line.
  - **EX:** If a line has a slope of -2 and contains the point $(5, -4)$, the equation is $y - (-4) = -2(x - 5)$ or $y + 4 = -2(x - 5)$.
- **Standard form:** $Ax + By = C$, where A, B, and C are integers and A is positive. The slope is $-\frac{A}{B}$ and the y-intercept is $\frac{C}{B}$. This form of a line is most often used to find intercepts by plugging 0 in for x and y separately and solving.
  - **EX:** Given the line $3x + 2y = 4$, the slope is $-\frac{3}{2}$ and the y-intercept is 2. The intercepts can also be found by substitution.
  - x-intercept (plug in 0 for y):
    $3x + 2y = 4 \quad 3x + 2(0) = 4 \quad 3x = 4 \quad x = \frac{4}{3}$
  - y-intercept (plug in 0 for x):
    $3x + 2y = 4 \quad 3(0) + 2y = 4 \quad 2y = 4 \quad y = 2$

Polynomial Functions

A function is a **polynomial function** if it can be written in the form
$$f(x) = ax^n + bx^{n-1} + cx^{n-2} + \ldots + dx + e.$$

- The greatest power of a polynomial with one variable is called its **degree**.
  - When the degree of the function is odd, there is at least one real zero; when the degree is even, there may be no real zero.
  - Both types can have imaginary roots of the form $a + bi$.
- **EX:** $f(x) = 2x^3 + 3x^2 - x + 4$ has a degree of 3, one real zero at $x = -2.1601\ldots$, and two non-real roots.

Quadratic Functions

Written in the form $f(x) = ax^2 + bx + c$, where $a \neq 0$

- The **axis of symmetry** is the vertical line with equation $x = -\frac{b}{2a}$.
- The y-intercept is c.
- Quadratic functions can be written in **vertex form**, $f(x) = a(x - h)^2 + k$, where (h, k) is the vertex of a parabola that opens up when $a > 0$ and opens down when $a < 0$.
- Quadratic functions can have none, one, or two real-number solutions.
- The graph is a parabola if the parabola opens left or right—it is not a function.
- The vertex is the **critical point** where the graph changes from increasing to decreasing or decreasing to increasing.

Methods for Finding Roots

Equation	Method	Justification	Solution
$x^2 - 9 = 0$	Square Roots	There is no x-term.	$x^2 - 9 = 0$ $x^2 = 9$ $x = 3$ or -3
$x^2 + 2x - 8 = 0$	Factoring	8 has only a few factors to check.	$x^2 + 2x - 8 = 0$ $(x + 4)(x - 2) = 0$ $x = -4$ or 2
$2x^2 + 5x - 9 = 0$	Quadratic Formula	The equation cannot be factored.	$x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ $x = \dfrac{-5 \pm \sqrt{5^2 - 4(2)(-9)}}{2(2)}$ $x = \dfrac{-5 \pm \sqrt{97}}{4}$
$x^2 - 8x + 3 = 0$	Completing the Square or Quadratic Formula	The coefficient of the x^2-term is 1 but the equation cannot be factored.	$x^2 - 8x + 3 = 0$ $x^2 - 8x = -3$ $x^2 - 8x + 16 = -3 + 16$ $x^2 - 8x + 16 = 13$ $(x - 4)^2 = 13$ $x - 4 = \pm\sqrt{13}$ $x = 4 \pm \sqrt{13}$

The **discriminant** is the expression under the radical in the Quadratic Formula and can be used to determine the number of real solutions.

Discriminant: $b^2 - 4ac > 0$
- **EX:** $2x^2 - 7x + 3 = 0$
- The discriminant is $(-7)^2 - 4(2)(3) = 25$, which is positive.
- There are two real number solutions.

Discriminant: $b^2 - 4ac = 0$
- **EX:** $x^2 - 8x + 16 = 0$
- The discriminant is $(-8)^2 - 4(1)(16) = 0$.
- There is one real number solution.

Discriminant: $b^2 - 4ac < 0$
- **EX:** $2x^2 - 7x + 8 = 0$
- The discriminant is $(-7)^2 - 4(2)(8) = -15$, which is negative.
- There are no real number solutions.

Rational Functions

A **rational function** is an equation of the form $f(x) = \frac{p(x)}{q(x)}$, where $p(x)$ and $q(x)$ are polynomial functions and $q(x) \neq 0$.

- Rational functions may have breaks in continuity that appear in the graph as vertical asymptotes or point discontinuities that appear as holes.
- Vertical asymptotes occur where a rational function is undefined.
- Point discontinuities occur where there is a common factor in the numerator and denominator.

To multiply: First multiply the numerators, then multiply the denominators.

To divide: Multiply by the multiplicative inverse (reciprocal) of the divisor.

⚠ Order is important for division.

To add and subtract: There must be a common denominator. To find it for rational expressions with polynomials in the denominator, factor first to determine common factors.

The common denominator is the **LCM** (least common multiple) of the denominators.

Adding: $\dfrac{3}{x^2 - x - 20} + \dfrac{7}{2x - 10}$
$= \dfrac{3}{(x - 4)(x - 5)} + \dfrac{7}{2(x - 5)}$

Using one of each factor, the LCM is $2(x + 4)(x - 5)$. Multiply each fraction's numerator and denominator by the factors missing from the LCM.

$= \dfrac{3}{(x + 4)(x - 5)} \cdot \dfrac{2}{2} + \dfrac{7}{2(x - 5)} \cdot \dfrac{(x + 4)}{(x + 4)}$
$= \dfrac{6}{2(x + 4)(x - 5)} + \dfrac{7x + 28}{2(x - 5)(x + 4)}$
$= \dfrac{7x + 39}{2(x - 5)(x + 4)}$

⚠ The subtraction sign must be distributed to each part of the numerator of the second fraction.

Subtracting: $\dfrac{h - 4}{h^2 - 3h - 10} - \dfrac{h - 2}{h^2 - 2h}$
$= \dfrac{h - 4}{(h - 5)(h + 2)} - \dfrac{h - 2}{h(h - 5)}$

Using one of each factor, the LCM is $h(h - 2)(h + 5)(h - 4)$.
Multiply each fraction's numerator and denominator by the factors missing from the LCM.

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