<u>Math 163A Handout 2: Mathematical Tools for Chapter 2</u>

Transformations of graphs	constant on the outside	constant on the inside
additive constant	$g(x) = f(x) + c$ Make graph of g by <u>adding</u> c to the y-values on the graph of f.	$g(x) = f(x+c)$ Make graph of g by <u>subtracting</u> c from the x-values on the graph of f.
multiplicative constant	$g(x) = cf(x)$ Make graph of g by <u>multiplying</u> the y-values on the graph of f by c.	$g(x) = f(cx)$ Make graph of g by <u>dividing</u> the x-values on the graph of f by c.

End behavior of polynomial graphs	even-degree polynomial	odd-degree polynomial
positive leading coefficient	graph goes up on both sides	graph goes up on right, down on left.
negative leading coefficient	graph goes down on both sides	graph goes down on right, up on left.

<u>Six Step Method for Graphing Rational Functions without Calculus</u>

Step 1: If $x = 0$ is in the domain, find $f(0)$.

Step 2: Check for symmetries.

Step 3: Determine the end behavior (horizontal asymptote? slant asymptote? power function?) by deciding which of the following three cases applies.

case 1: degree of numerator < degree of denominator

In this case, the end behavior will resemble $y = \frac{1}{x^m}$. So the line $y = 0$ will be a horizontal asymptote.

case 2: degree of numerator = degree of denominator

In this case, the end behavior will resemble $y = \frac{ax^m}{bx^m} = \frac{a}{b}x^0 = \frac{a}{b}$. So the line $y = \frac{a}{b}$ will be a horizontal asymptote.

case 3: degree of numerator > degree of denominator

case 3a: degree of numerator = 1 + degree of denominator

In this case, the the end behavior will resemble $y = \frac{ax^{m+1}}{bx^m} = \frac{a}{b}x$. So, the line $y = \frac{a}{b}x$ will be a slant asymptote.

case 3b: degree of numerator $\geq$ 2 + degree of denominator

In this case, the end behavior will resemble $y = x^m$, for some integer $m \geq 2$.

Step 4: Make a sign chart for f. To do this, factor the function (both numerator and denominator). This will enable you to determine the domain of the function, and it will also tell you the important x-values for f. (If a linear factor $(x-r)$ appears in the factorization, then the number r is an important x-value.) Then, put all the important x-values on a number line. In each region and at each important x-value, determine whether f is positive, negative, zero, or undefined.

Step 5: Locate vertical asymptotes, holes, and x-intercepts by examining the linear factors in the factorization. For each linear factor $(x-r)$ in the factorization, decide which of the following five cases applies.

case 1: The linear factor $(x-r)$ appears in the numerator but not in the denominator.

In this case, the graph will have an x-intercept at $x = r$.

case 2: The linear factor $(x-r)$ appears in both the numerator and denominator but with a larger exponent in the numerator.

In this case, the graph will cross the x-axis at $x = r$, but there will be a hole at the crossing.

case 3: The linear factor $(x-r)$ appears in both the numerator and in the denominator and with equal exponents.

In this case, the graph will have a hole at $x = r$.

case 4: The linear factor $(x-r)$ appears in both the numerator and denominator but with a smaller exponent in the numerator.

In this case, the graph will have a vertical asymptote at $x = r$.

case 5: The linear factor $(x-r)$ appears in the denominator only.

In this case, the graph will have a vertical asymptote at $x = r$.

Step 6: Based on the analysis in steps 1 through step 5, sketch the graph of f.