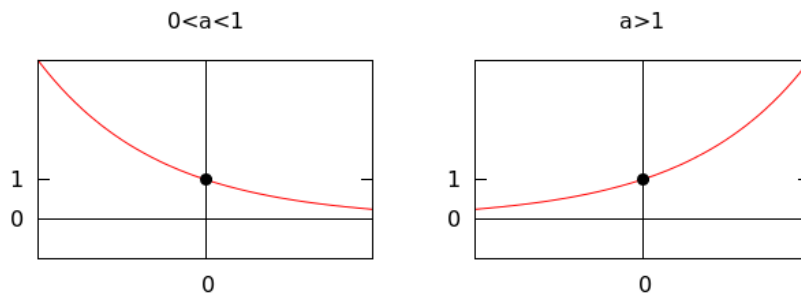# 4.2: Exponential Functions

Supplementary Notes

$$f(x) = a^x \qquad (a > 0, a \neq 1)$$

where a is a real number. Below are the graphs of f both for $0 < a < 1$ and $a > 1$.

The graph of f has the following properties

- domain: $(-\infty, \infty)$

- range: $(0, \infty)$

- $y-$intercept: 1

- horizontal asymptote: $y = 0$ $(x-\text{axis})$

- $\begin{cases} \text{increasing} & \text{if } a > 1 \\ \text{decreasing} & \text{if } 0 < a < 1 \end{cases}$

Below are laws of exponents and rules for transforming graphs of exponential functions, some of which are review from Section 3.2

Laws of Exponents		
$a^s \cdot a^t = a^{s+t}$	$(a^s)^t = a^{s \cdot t}$	$(a \cdot b)^s = a^s \cdot b^s$
$a^{-s} = \frac{1}{a^s} = \left(\frac{1}{a}\right)^s$	$1^s = 1$	$a^0 = 1$

Reflection		
To obtain the graph of		
$-a^x$	reflect the graph of a^x about the	x-axis
a^{-x}	reflect the graph of a^x about the	y-axis

Translation		
For $h, k > 0$, to obtain the graph of		
$a^x + k$	translate the graph of a^x	upward k units
$a^x - k$	translate the graph of a^x	downward k units
a^{x-h}	translate the graph of a^x	rightward h units
a^{x+h}	translate the graph of a^x	leftward h units

Reflection and Translation		
For $h, k > 0$, to obtain the graph of		
$-a^x + k$	reflect the graph of a^x	about the x−axis
	then translate the graph of $-a^x$	upward k units
$-a^x - k$	reflect the graph of a^x	about the x−axis
	then translate the graph of $-a^x$	downward k units
a^{-x-h}	translate the graph of a^x	rightward h units
	then reflect the graph of a^{x-h}	about the $y - axis$
a^{-x+h}	translate the graph of a^x	leftward h units
	then reflect the graph of a^{x+h}	about the $y - axis$

Exercises

1. Select the graph of $y = -b^x$, $b > 1$.

2. Select the graph of $y = a^{-(1+x)}$, $1 < a$.

3. Select the graph of $y = 1 - a^x$, $0 < a < 1$.

4. Select the graph of $y = -(\frac{1}{a})^x$, $0 < a < 1$.