

Thumbs up
Family 1.

Graphing

Math 108 - Chapter 4 - Family of graphs

Lines

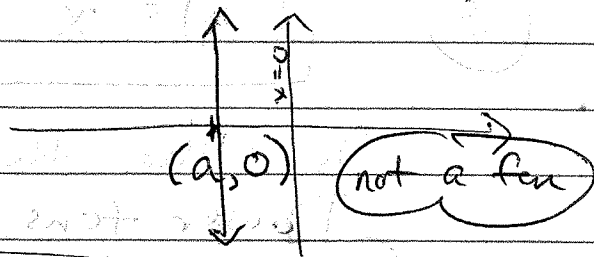
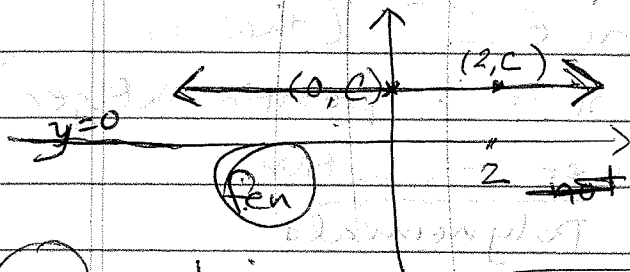
$$y = c$$

for all x

$$x = a$$

for all y

where a, c are constants.

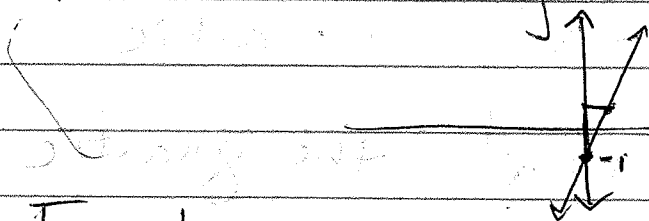


2.

Lines

$$y = mx + b$$

where m is the slope of the line, positive, negative, or zero, and b is the y -intercept of the line, that is, the value of y when $x=0$.



$y = 2x - 1$
 m is positive
so slope goes up

For lines, rewriting as $y = f(x)$ shows the functional nature of the graph.

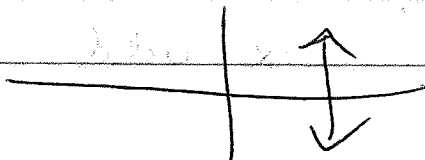
$$f(x) = c \quad \text{and} \quad f(x) = mx + b$$

pass the vertical line test, but

$$x = a$$

is not a function b/c, clearly, it fails the VLT.

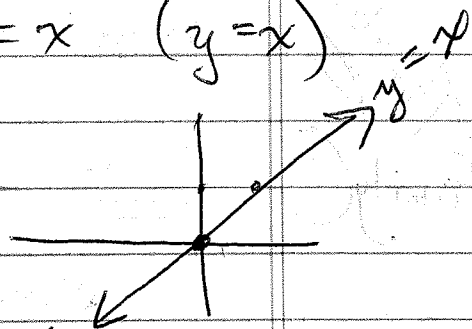
vertical line b/c it is a vert. line



Finally, we refer to $f(x) = x$ ($y = x$) as the "identity function".

$$y = \frac{1}{1}x \quad m = 1 \quad b = 0$$

$$y = 1x + 0$$



3.

$$f(x) = x^n$$

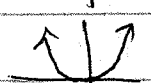
$n \in \mathbb{Z}^+$ (that is, n is a positive integer)

is called the "power function".

Power functions are polynomials.

Consider these values for n :

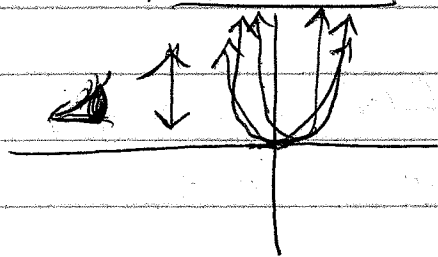
 $n = 1$ $f(x) = x^1$ the identity function (line)

 $n = 2$ $f(x) = x^2$ the parabola

 $n = 3$ $f(x) = x^3$ the cubic

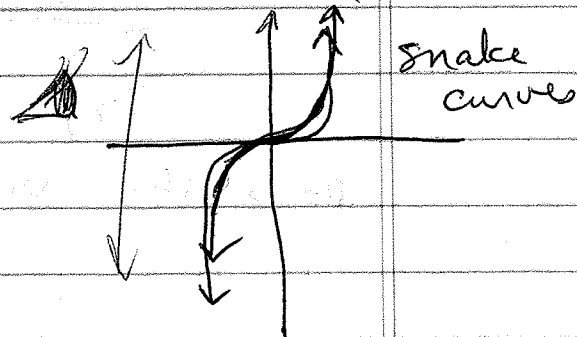
 $n = 4$ $f(x) = x^4$ the quartic

n even



U-shaped curves

n odd



snake curves

Domain: $x \in \mathbb{R}$ true of all polynomials
Range: n odd or even

Range: x even, $y \geq 0$
 x odd $-\infty < y < \infty, \mathbb{R}$

$f(x) = x^n$ features

Domain? $x \in \mathbb{R}$ since power fns. are polynomials

Range? Depends on n odd or even
 n Even: $y \geq 0$ n Odd: $\mathbb{R}$

Fcn Even or odd? : n even $\rightarrow f(x)$ even
 n odd $\rightarrow f(x)$ odd

Symmetric
about
y-axis

$\leftarrow$ Ex. $f(x) = x^2$
 $f(-x) = (-x)^2 = x^2 \Rightarrow f(x) = f(-x)$

Symmetric
about
origin

$\leftarrow$ Ex $f(x) = x^3$
 $f(-x) = (-x)^3 = (-1)^3 x^3 = -x^3 \Rightarrow f(-x) = -f(x)$

Sum
up

$f(x) = x^{\text{odd}}$
 $f(x) = x^{\text{even}}$

$f(-x) = -f(x)$ an odd fcn
 $f(x) = f(-x)$ an even fcn.

One-to-one? $f(a) = f(b) \Rightarrow a = b$ if $f(a) = f(b)$ then a is equal to b

Even power fns. are clearly not one-to-one since they fail the horizontal line test.

Ex $f(x) = x^{\text{even}}$
 $f(1) = 1 = 1 = f(-1)$
 $f(-1) = 1^{\text{odd}} = -1 \neq f(1)$
 $\underbrace{\hspace{10em}}_{\text{not equal}}$

Look carefully at graphs on pp 93-97
+ at the "Important Ideas" which
sum up the features of power fns.

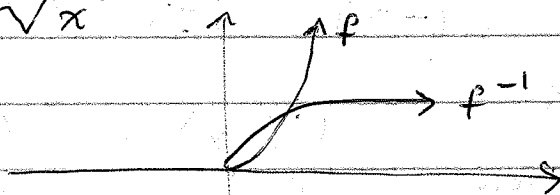
Root functions $f(x) = x^{\frac{1}{n}}$

First + foremost, these are the inverse
fns. of the power fns. on the
appropriate domain.

9/30 Root fns + Rational (reciprocal) fns.

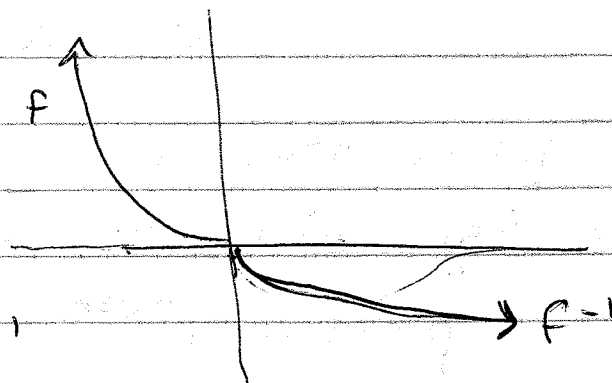
The inverse fn. of $f(x) = x^2$ that exists on $[0, \infty)$
is $f^{-1}(x) = \sqrt{x}$

$\text{Dom } f = \text{Range } f^{-1}$



The inverse fn. of $f(x) = x^2$ on $(-\infty, 0]$
is $f^{-1}(x) = -\sqrt{x}$

$\text{Dom } f = \text{Range } f^{-1}$



$\text{Range } f = \text{Dom } f^{-1}$

$y = x^2 \rightarrow$ on $\mathbb{R}$ / negatives

$$x = y^2$$

$$\sqrt{x} = \sqrt{y^2}$$

$$\pm \sqrt{x} = y$$

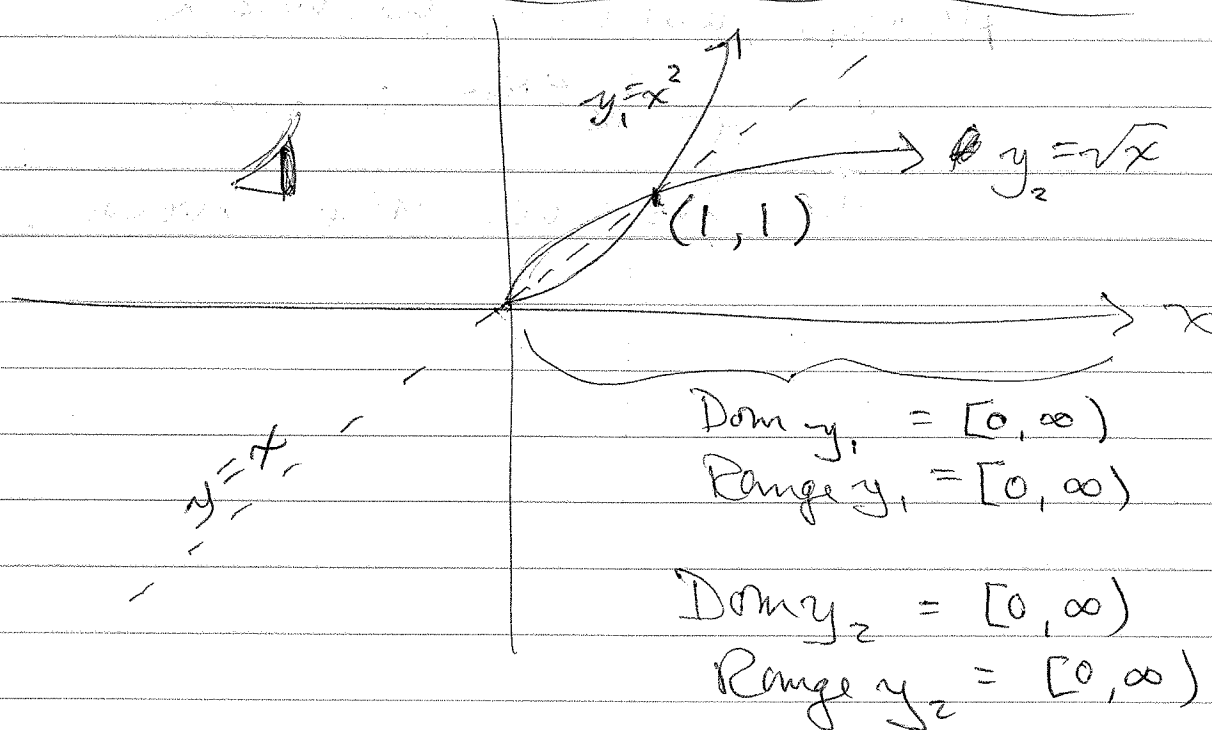
For f & f^{-1} ,

we find $\text{dom } f$

$$= \text{range } f^{-1}$$

$$\text{and } \text{range } f = \text{dom } f^{-1}$$

Power fens have root fens as inverses



"Root fen" means square root fen,
but "root-fens" is a catch-all

for $\boxed{y = \sqrt{x}}$

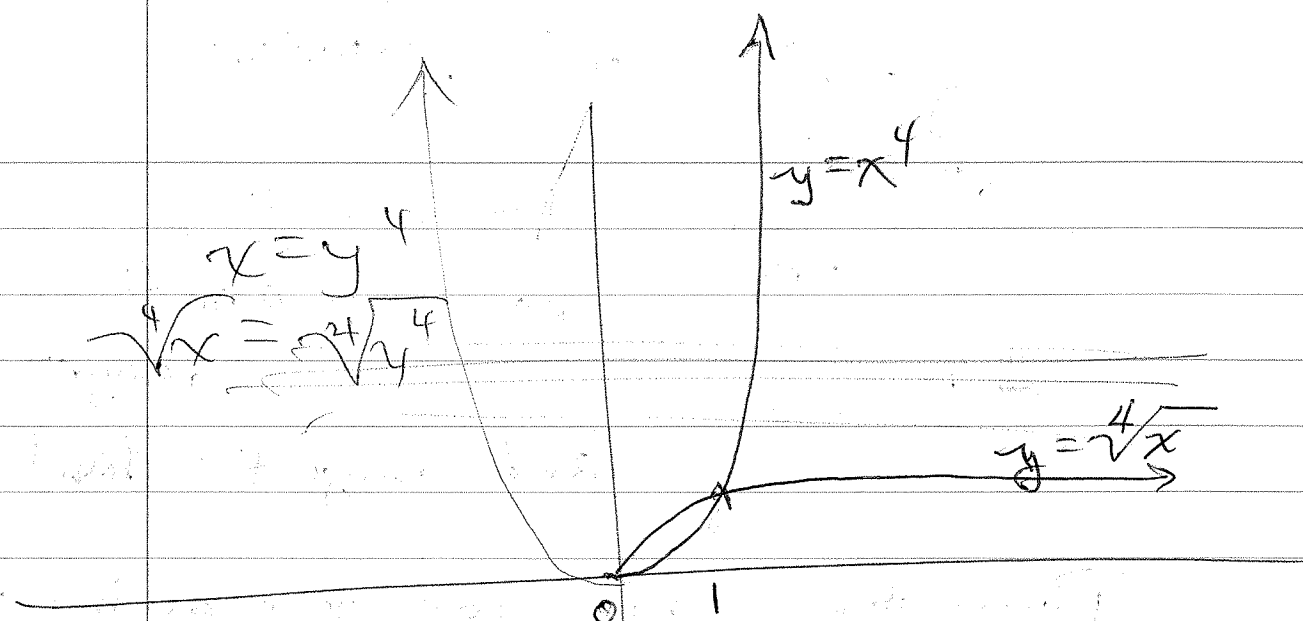
$$y_1 = y_2$$

$$x^2 = \sqrt{x}$$

soln to the system

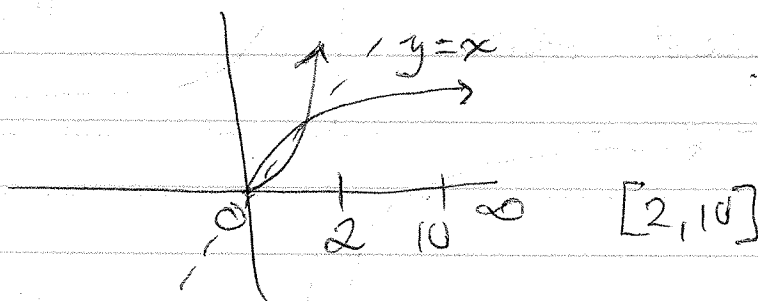
$$\boxed{x = 0, 1}$$

"pts of intersection"



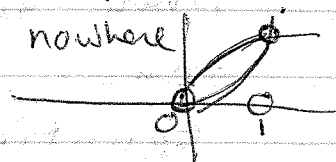
Always restrict the domain
of $y = x^{\text{even}}$ in order
to discover the inverse.

Draw the axis of symmetry $y=x$ to see the inverse nature of $f(x)=x^2$ & $g(x)=\sqrt{x}$



Where do $y=x^2$ & $y=\sqrt{x}$ intersect on $[0, \infty)$? On $(0, 1)$?
 $(0,0) + (1,1)$ open interval

~~On $(0, 1)$~~



Reciprocal fun. - the simplest kind of rational fun. function

i.e., fns of the form $\frac{f(x)}{g(x)} = y$
 functions

are "rational ~~fun~~ fns". If $f(x)=1$ and $g(x)=x$, we get the simplest of these,

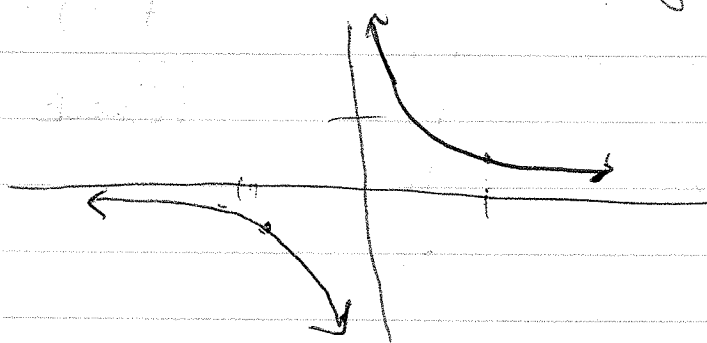
$\frac{1}{x}$ reciprocal of x

$$y = \frac{1}{x} = \frac{f(x)}{g(x)}$$

Dom: $x \neq 0$

Range: ?

x	y
-2	-1/2
-1	-1
0	∞
1	1
2	1/2

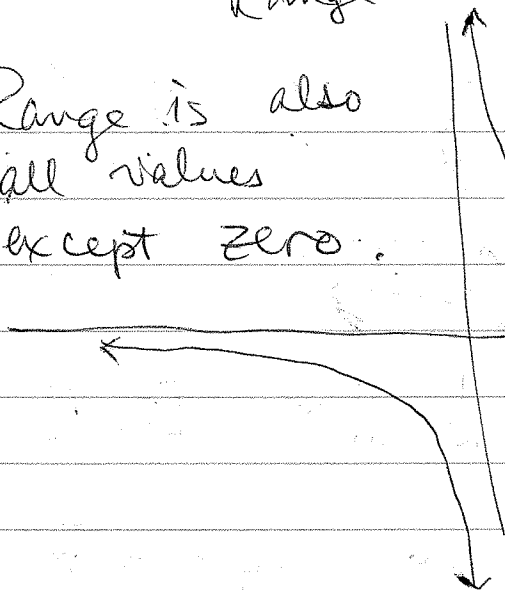


x	y
-1	-1
-1/2	-2
-1/4	-4
0	∞
1/4	4
1/2	2
1	1

$$\text{Dom} = (-\infty, 0) \cup (0, \infty) \text{ or } x \neq 0$$

$$\text{Range} = (-\infty, 0) \cup (0, \infty) \text{ or } y \neq 0$$

Range is also
all values
except zero.



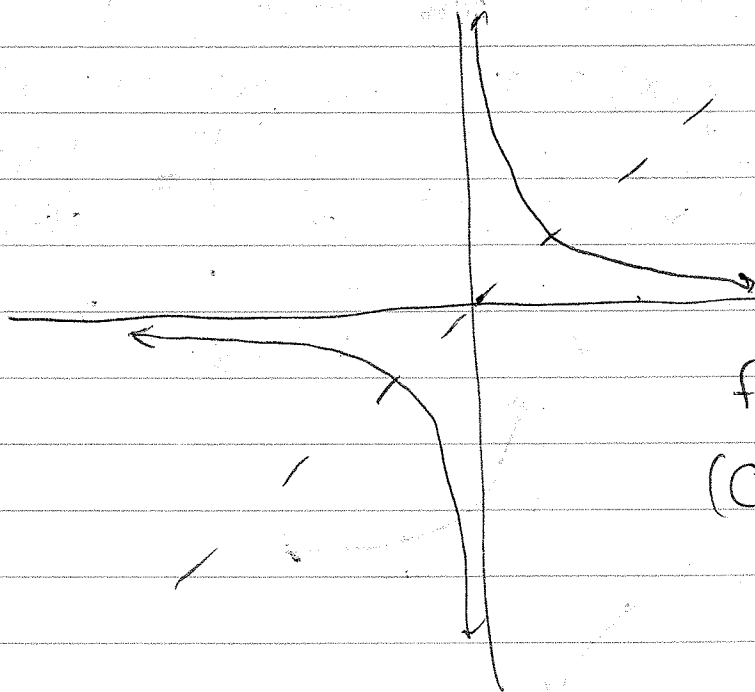
Since the axes are
not crossed but
the graph gets
"infinitesimally
close" to
them, we say
the axes are
the asymptotes.

When you name the asymptotes of a
fcn., you must name them as an
equation:

$x = 0$ vertical asymptote

$y = 0$ horizontal asymptote

Draw the line $y = x$ on this graph.



Notice that the
fcn. serves as
its own inverse.

$$f(x) = \frac{1}{x}, f^{-1}(x) = \frac{1}{x}$$

(Check $f \circ f^{-1}$, $f^{-1} \circ f$)

Finally, $f(x) = \frac{1}{x}$ is odd because

$$f(-x) = \frac{1}{-x} = -\frac{1}{x} = -f(x)$$

It's one-one because if we assume ~~there~~

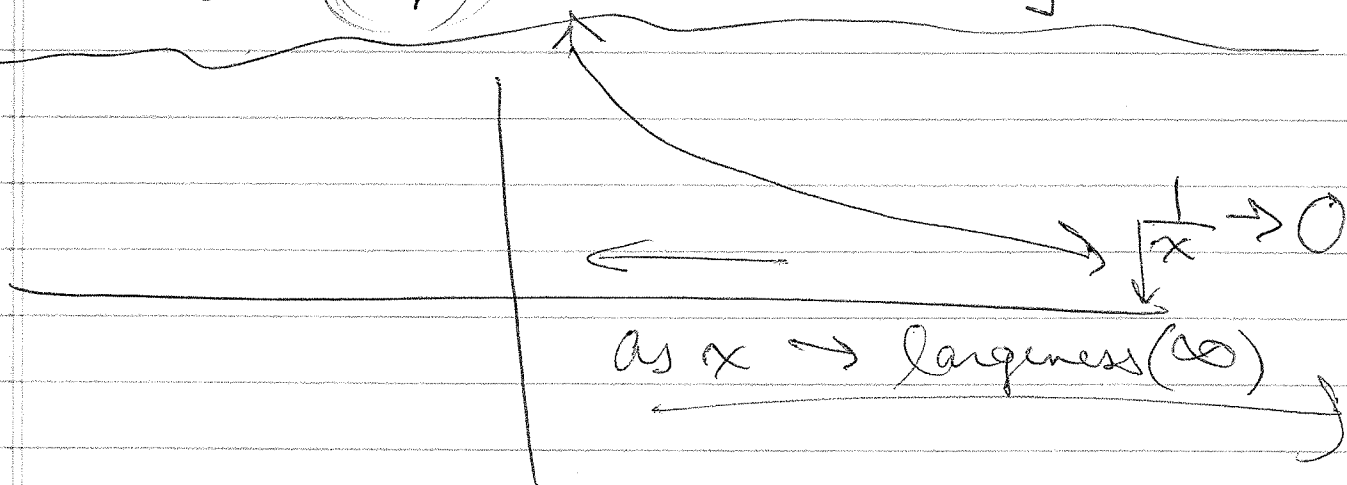
If $f(a) = f(b)$ $\rightarrow$
(that is, $\hookrightarrow \frac{1}{a} = \frac{1}{b}$)

then clearly $a = b$. ✓

We can anticipate the ^{idea} ~~idea~~ of the limit of a fcn. by studying $y = \frac{1}{x}$

as x gets very large or very small.

$$y = \frac{1}{\text{huge}} \approx 0, \quad y = \frac{1}{\text{tiny}} \approx \infty$$



Domain: $y = \frac{1}{x} \quad (-\infty, 0) \cup (0, \infty)$

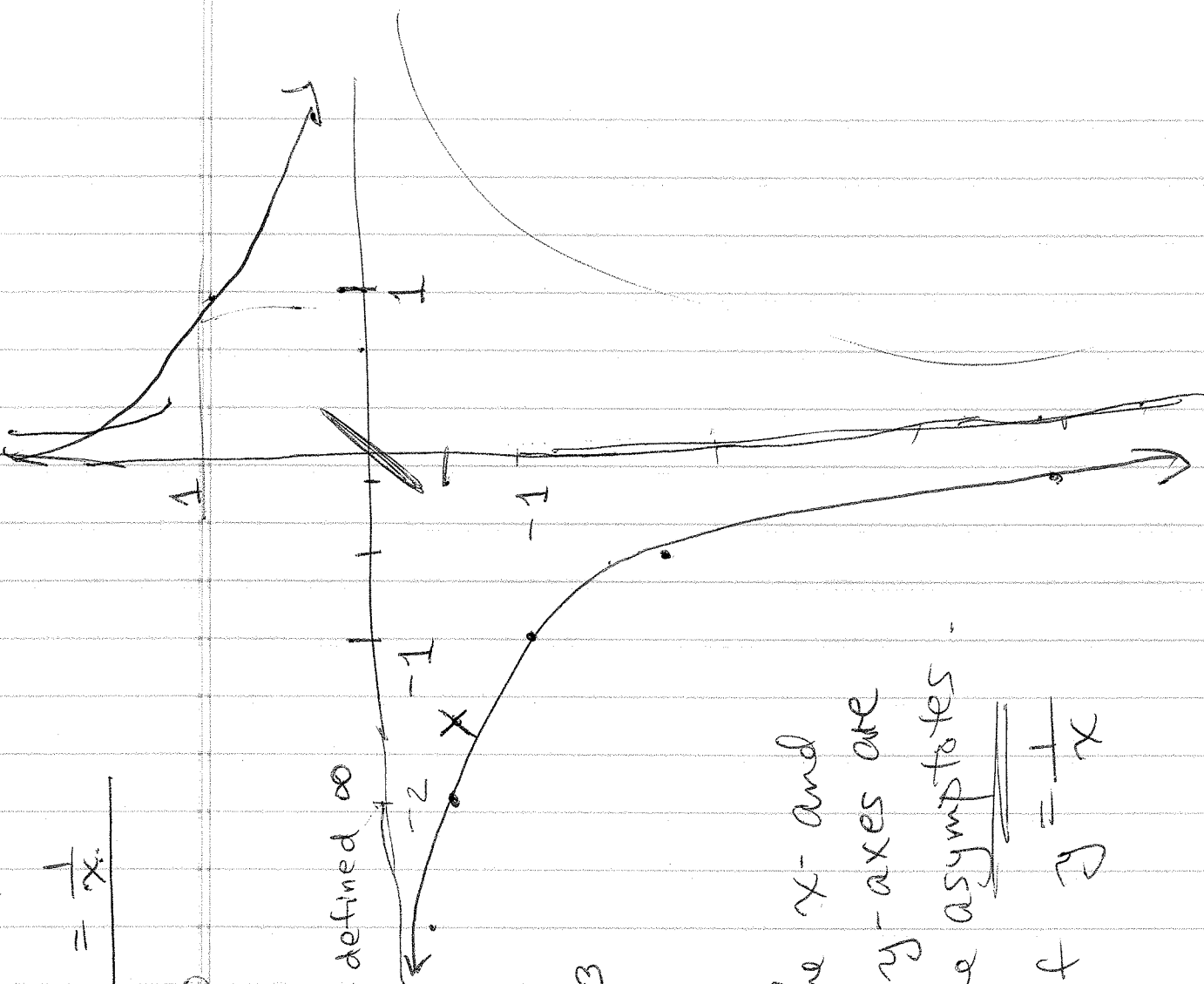
Range:

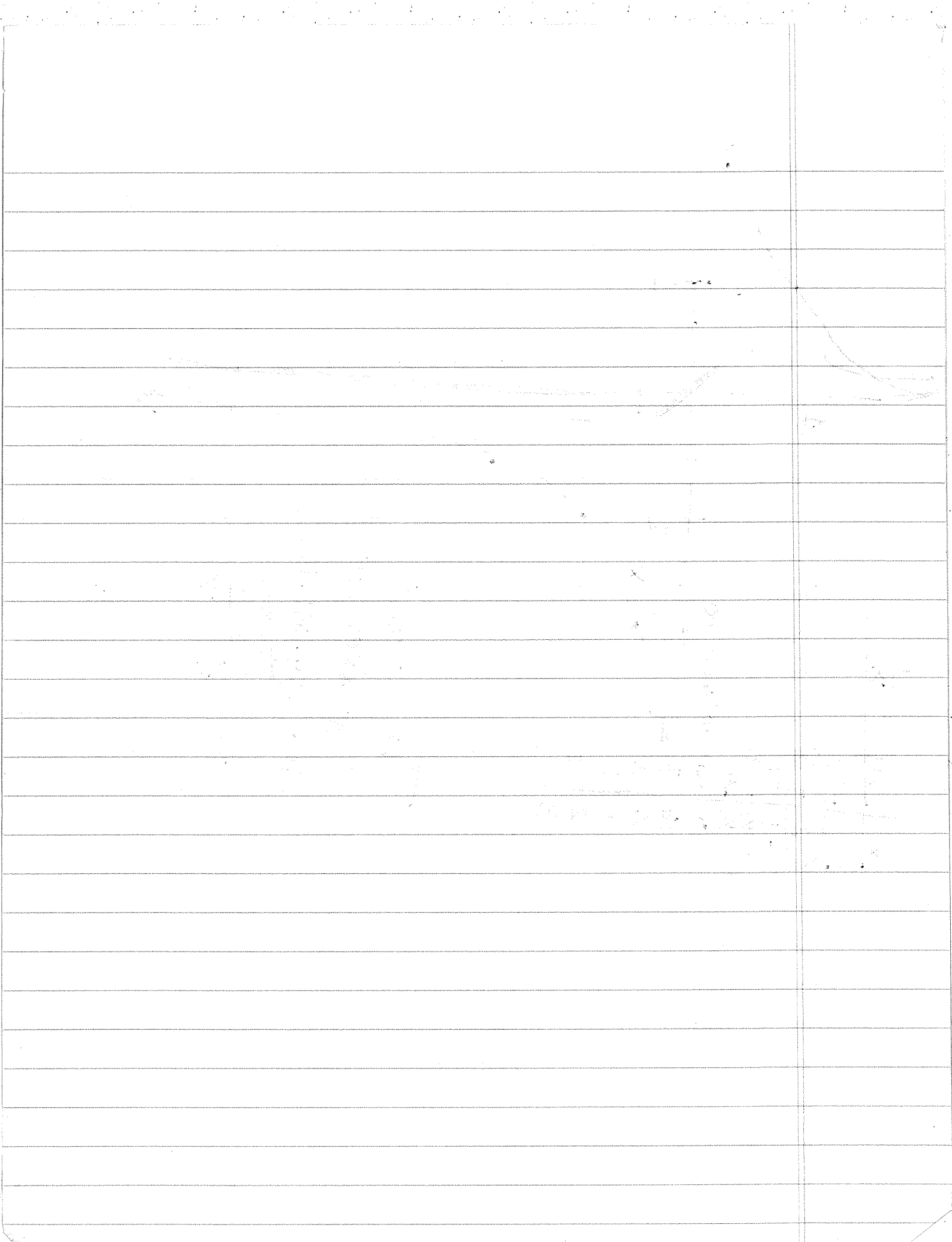
Transformations

(1) $\frac{1}{2} \rightarrow \frac{1}{4}$ $\frac{1}{4} \rightarrow \frac{1}{8}$ $\frac{1}{8} \rightarrow \frac{1}{16}$ $\frac{1}{16} \rightarrow \frac{1}{32}$ $\frac{1}{32} \rightarrow \frac{1}{64}$ $\frac{1}{64} \rightarrow \frac{1}{128}$ $\frac{1}{128} \rightarrow \frac{1}{256}$ $\frac{1}{256} \rightarrow \frac{1}{512}$ $\frac{1}{512} \rightarrow \frac{1}{1024}$ $\frac{1}{1024} \rightarrow \frac{1}{2048}$ $\frac{1}{2048} \rightarrow \frac{1}{4096}$ $\frac{1}{4096} \rightarrow \frac{1}{8192}$ $\frac{1}{8192} \rightarrow \frac{1}{16384}$ $\frac{1}{16384} \rightarrow \frac{1}{32768}$ $\frac{1}{32768} \rightarrow \frac{1}{65536}$ $\frac{1}{65536} \rightarrow \frac{1}{131072}$ $\frac{1}{131072} \rightarrow \frac{1}{262144}$ $\frac{1}{262144} \rightarrow \frac{1}{524288}$ $\frac{1}{524288} \rightarrow \frac{1}{1048576}$ $\frac{1}{1048576} \rightarrow \frac{1}{2097152}$ $\frac{1}{2097152} \rightarrow \frac{1}{4194304}$ $\frac{1}{4194304} \rightarrow \frac{1}{8388608}$ $\frac{1}{8388608} \rightarrow \frac{1}{16777216}$ $\frac{1}{16777216} \rightarrow \frac{1}{33554432}$ $\frac{1}{33554432} \rightarrow \frac{1}{67108864}$ $\frac{1}{67108864} \rightarrow \frac{1}{134217728}$ $\frac{1}{134217728} \rightarrow \frac{1}{268435456}$ $\frac{1}{268435456} \rightarrow \frac{1}{536870912}$ $\frac{1}{536870912} \rightarrow \frac{1}{1073741824}$ $\frac{1}{1073741824} \rightarrow \frac{1}{2147483648}$ $\frac{1}{2147483648} \rightarrow \frac{1}{4294967296}$ $\frac{1}{4294967296} \rightarrow \frac{1}{8589934592}$ $\frac{1}{8589934592} \rightarrow \frac{1}{17179869184}$ $\frac{1}{17179869184} \rightarrow \frac{1}{34359738368}$ $\frac{1}{34359738368} \rightarrow \frac{1}{68719476736}$ $\frac{1}{68719476736} \rightarrow \frac{1}{137438953472}$ $\frac{1}{137438953472} \rightarrow \frac{1}{274877906944}$ $\frac{1}{274877906944} \rightarrow \frac{1}{549755813888}$ $\frac{1}{549755813888} \rightarrow \frac{1}{1099511627776}$ $\frac{1}{1099511627776} \rightarrow \frac{1}{2199023255552}$ 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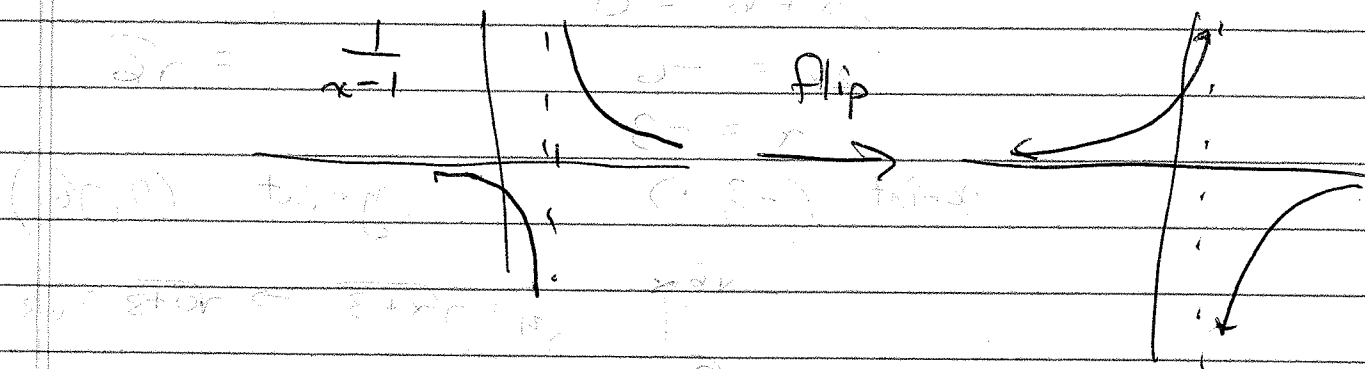
$y = \frac{1}{x}$	
x	y
-3	$-\frac{1}{3}$
-2	$-\frac{1}{2}$
-1	-1
$-\frac{1}{2}$	-2
$-\frac{1}{4}$	-4
0	not defined ∞
$\frac{1}{4}$	4
$\frac{1}{2}$	2
1	1
2	$\frac{1}{2}$
3	$\frac{1}{3}$

The x - and y -axes are the asymptotes of $y = \frac{1}{x}$





$$y = \frac{1}{-x+1} = \frac{1}{-(x-1)}$$



10/2

So far, we've only graphed rigid transformations of our three basic fens. (power, root, reciprocal)

Non-rigid transformations entail a multiplier of x .

$$y = 2x^2$$

$$y = \sqrt{3x}$$

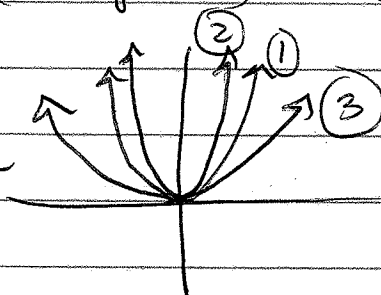
Change
their
shape

$$y = \frac{-4}{x}$$

in terms of their wideness or narrowness.
(compress) (stretch)

$$\textcircled{2} y = 3x^2$$

$$\textcircled{3} y = \frac{x^2}{4} = \frac{1}{4}x^2$$



p. 159 Do Comp. Check

$$y = \sqrt{2x+6} = 0$$

$$2x+6=0$$

$$2x = -6$$

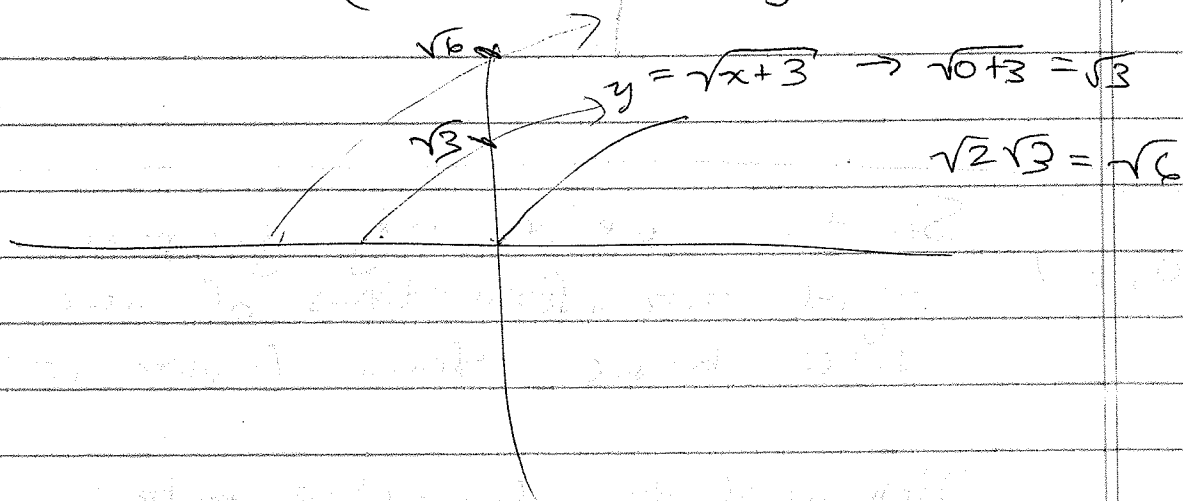
$$x = -3$$

x-int $(-3, 0)$

$$y = \sqrt{2 \cdot 0 + 6} =$$

$$= \sqrt{6}$$

y-int $(0, \sqrt{6})$

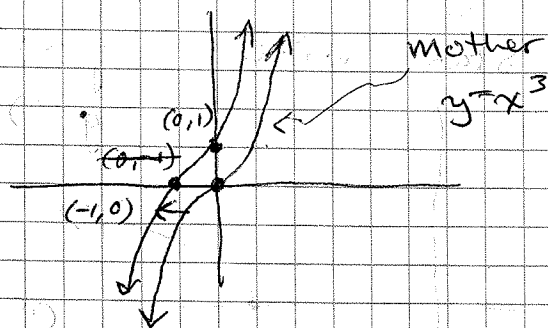


4.2

1a $g(x) = (x+1)^3$

y-int $g(0) = (0+1)^3 = 1$

root $0 = (x+1)^3$
(x-int) $x = -1$

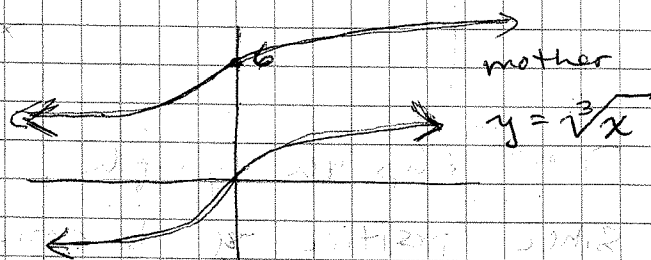


1b $g(x) = \sqrt[3]{x} + 6$

$g(0) = \sqrt[3]{0} + 6 = 6$

$0 = \sqrt[3]{x} + 6$

$x = (-6)^3 = -216$ (too far out to graph)

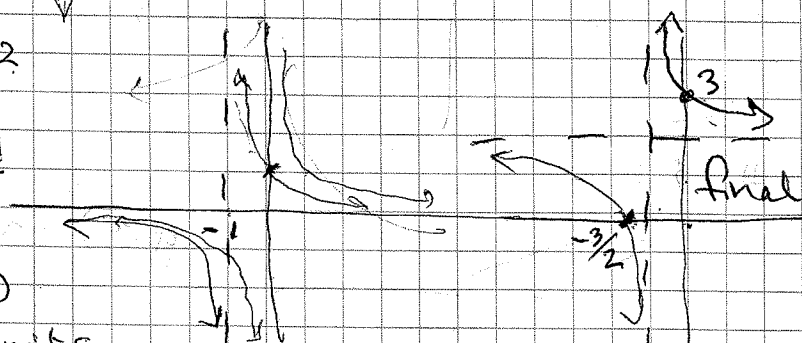


1c $g(x) = \frac{1}{x+1} + 2$

Vert. Asymptote $x = -1$

Horiz. Asymptote $y = 0$
(x-axis)

Now move it up 2 units
(check y-int, any roots,
change in asymptotes?)



$g(0) = 1 + 2 = 3$

$0 = \frac{1}{x+1} + 2$

$-2 = \frac{1}{x+1}$

$x+1 = -\frac{1}{2}$

$x = -\frac{3}{2}$

Notice the change in
the horizontal asymptote:

$g(x) = \frac{1}{x+1} \rightarrow 0$ as $x \rightarrow \infty$

But $\frac{1}{x+1} + 2 \rightarrow 0 + 2$ as $x \rightarrow \infty$

So HA is $y = 2$ eqns of lines
while VA is still $x = -1$

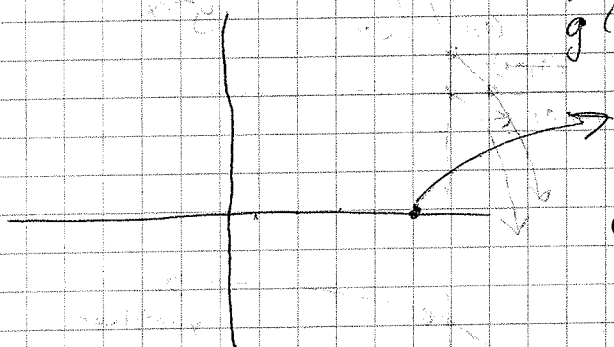
$$g(x) = -\sqrt{x-5}$$

Start with

$$g(x) = \sqrt{x-5}$$

$g(0)$ = undefined = since

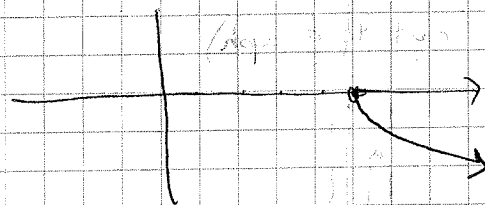
Dom g $x \geq 5$ (so there's no y -int)



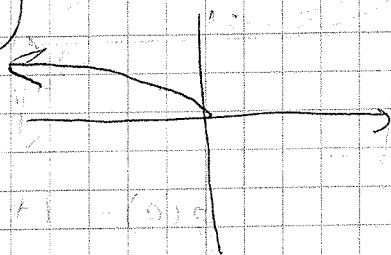
$$0 = \sqrt{x-5}$$

$x = 5$ is the x -intercept (root)

Now flip the graph, that is, reflect it over x -axis
Since positive y becomes negative



#1 i



$$g(x) = \sqrt{-x} \quad \text{Dom: } -x \geq 0$$

$$x \leq 0$$

#1 l

$$g(x) = \sqrt{-x+1} - 2$$

"Mother fun" is $\sqrt{-x} = y$ (above)

What happens to the root?

$$0 = \sqrt{-x+1} - 2$$

$$2 = \sqrt{-x+1}$$

$$4 = 1-x \longrightarrow x = -3 \text{ is new root (x-int)}$$

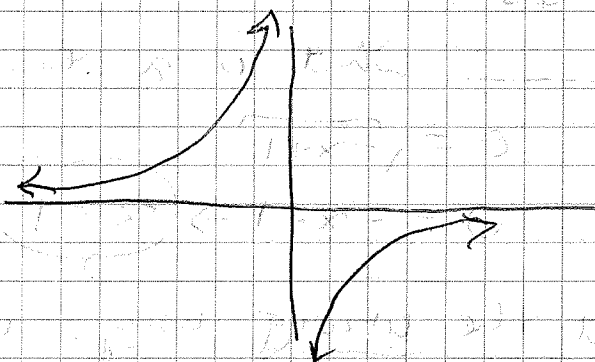
What is y -int?

$$g(0) = \sqrt{0+1} - 2 = -1 = y \text{ is new } y\text{-int}$$

#1 n

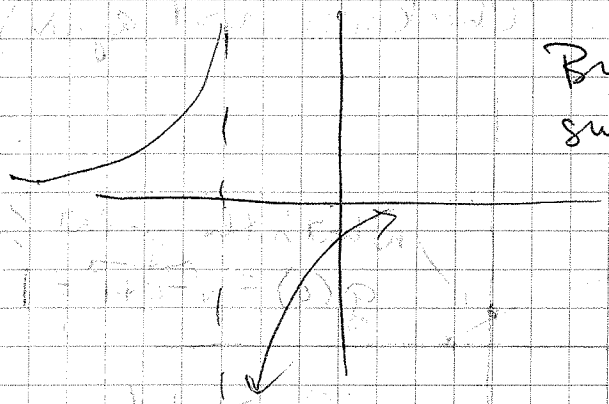
$$g(x) = \frac{1}{-x+3}$$

Mother is $y = \frac{1}{-x}$



What is the shift? 3 right or left?

We know from last problem that this is deceptive. If we went left it would look like this



But what is the vert. asympt. supposed to be?

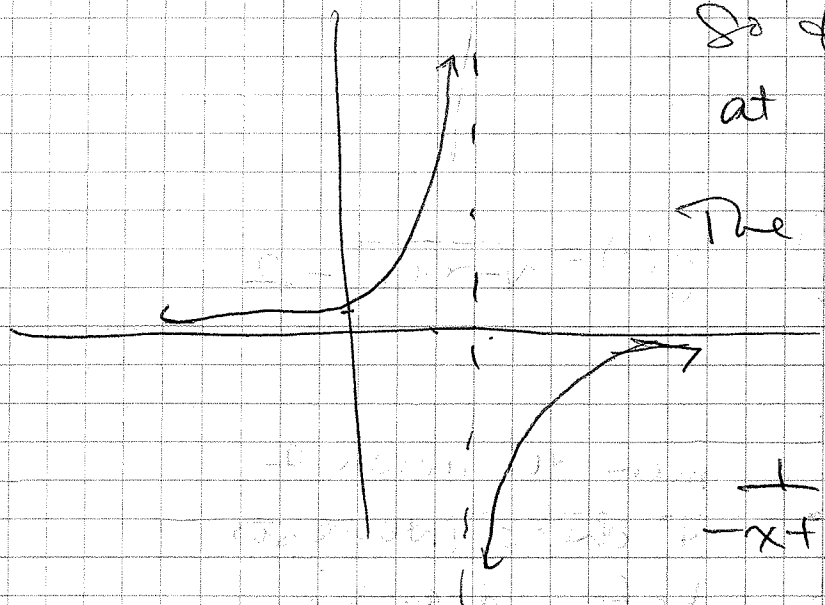
$$g(x) = \frac{1}{-x+3}$$

$$VA: -x+3 \neq 0$$

$$x \neq 3$$

So the graph has the VA at $x = 3$

The horiz. asympt. is still $y = 0$ (x-axis)



Since

$$\frac{1}{-x+3}$$

$\rightarrow 0$ as $x \rightarrow \infty$ or $-\infty$

~~new~~