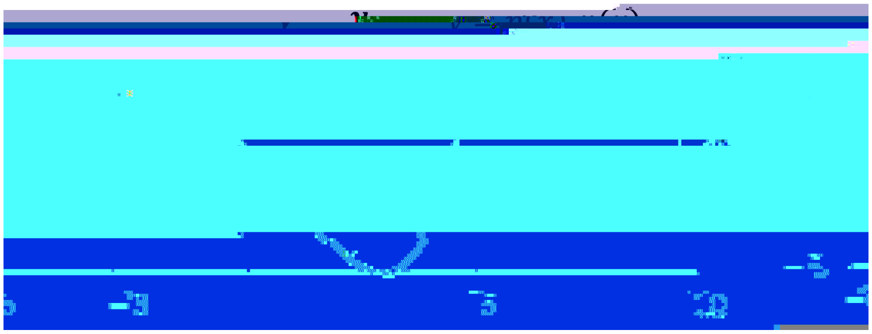
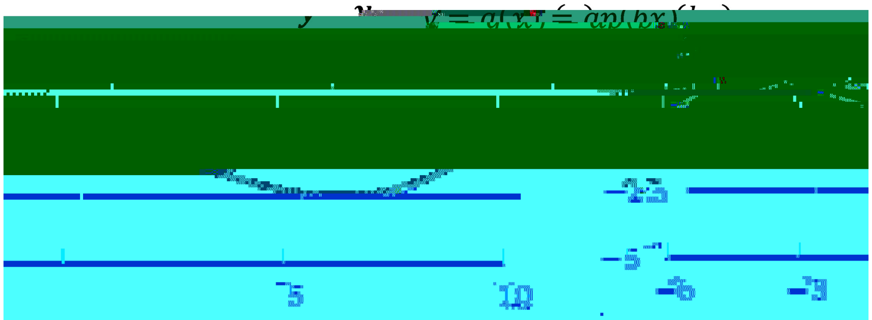
1. (20 pts) Parts (a) and (b) are not related.

   (a) For $f(x) = \frac{1}{x \quad 1}$ and $g(x) = \sqrt{2 \quad x}$

(b) The graphs below depict the functions $y = p(x)$ and $y = q(x)$, where $q$ is a transformation of $p$ of the form $q(x) = ap(bx)$. Find the values of $a$ and $b$.





**Solution:**

The vertical difference between the maximum and minimum values of the curve for $p(x)$ is $3 \quad ( \quad 5) = 8$, while the vertical difference between the maximum and minimum values of the curve for $q(x)$ is $1{:}5 \quad ( \quad 2{:}5) = 4$. Therefore, the curve for $q(x)$ has been constructed by applying a vertical contraction of a factor of 2 to the curve for $p(x)$. This implies that $\boxed{a = 1{=}2}$

The horizontal difference between the endpoints of the curve for $p(x)$ is $5 \quad ( \quad 3) = 8$, while the horizontal difference between the endpoints of the curve for $q(x)$ is $10 \quad ( \quad 6) = 16$. Therefore, the curve for $q(x)$ has been constructed by applying a horizontal expansion of a factor of 2 to the curve for $p(x)$. This implies that $\boxed{b = 1{=}2}$

Note that $q(x) = 0{:}5\,p(0{:}5x)$.

(b) $\lim_{x \to 2} \frac{\sqrt{x+1} - \sqrt{3}}{x^2 + x - 6}$

**Solution:**

Begin by multiplying the numerator and the denominator by the conjugate of the original numerator expression.

$$\lim_{x \to 2} \frac{\sqrt{x+1} - \sqrt{3}}{x^2 + x - 6} = \lim_{x \to 2} \frac{\sqrt{x+1} - \sqrt{3}}{x^2 + x - 6} \cdot \frac{\sqrt{x+1} + \sqrt{3}}{\sqrt{x+1} + \sqrt{3}}$$

x

$$= \lim_{x \to 2}$$

3. (30 pts) Consider the rational function $r(x) = \quad 3x^2 + 21$

(c) Find the equation of each vertical asymptote of $y = r(x)$, if any exist. Support your answer in terms of your work in part (b).

**Solution:**

The finite value of $\lim_{x \to 5} r(x) = \frac{9}{8}$ determined in part (b) indicates that there is no vertical asymptote at $x = 5$.

The infinite limits $\lim_{x \to 3} r(x) = \infty$ and $\lim_{x \to 3^+} r(x) = \infty$ were determined in part (b). Either one of those limits being infinite is sufficient to conclude that the line $\boxed{x = 3}$ y (x , i. 0 (x), [f-500(exist.3.5 41-6 [(4950)]TJ/F3

4. (20 pts) Parts (a) and (b) are not related.

(a) For what value of $a$ is the following function $u(x)$ continuous at $x = 4$? Support your answer using the definition of continuity, which includes evaluating the appropriate limits.

$$u(x) = \begin{cases} \dfrac{x-4}{x^2-16} & ; \quad x < 4 \\[2ex] \dfrac{1}{a-x} & ; \quad x \geq 4 \end{cases}$$

**Solution:**

By the definition of continuity, $u(x)$ is continuous at $x = 4$ if $\lim\limits_{x \to 4^-} u(x) = \lim\limits_{x \to 4^+} u(x) = u(4)$.

$$\lim_{x \to 4^-} u(x) = \lim_{x \to 4^-} \frac{x-4}{x^2-16} = \lim_{x \to 4^-} \frac{x-4}{(x-4)(x+4)} = \lim_{x \to 4^-} \frac{1}{x+4} = \frac{1}{4+4} = \frac{1}{8}$$

$$\lim_{x \to 4^+} u(x) = \lim_{x \to 4^+} \frac{1}{a-x} = \frac{1}{a-4}$$

$$u(4) = \frac{1}{a-4}$$

Therefore, $u(x)$ is continuous at $x = 4$ if $\frac{1}{8} = \frac{1}{a-4}$, which occurs when $\boxed{a = 12}$

(b)