1. Sketch the graph $y = f(x)$ of a function which has all of the following properties; do not worry about any *formula* for $f(x)$:

(a) $f(0) = 3$

(b) $\lim_{x\to 0} f(x) = 0$

(c) $\lim_{x\to -2^-} f(x) = 1$

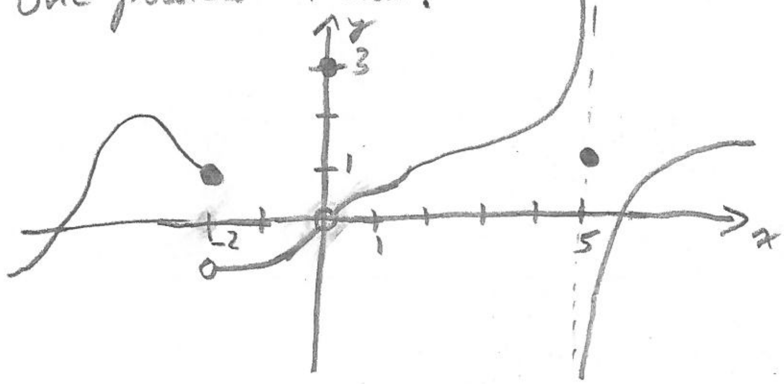
(d) $\lim_{x\to -2^+} f(x) = -1$

(e) $\lim_{x\to 5^-} f(x)$ d.n.e.

(f) $\lim_{x\to 5^+} f(x) = -\infty$

(g) the domain of f is $(-\infty, \infty)$

One possible answer:



2. Evaluate the limit, if it exists:

$$\lim_{h\to 0} \frac{(2+h)^3 - 8}{h} = \lim_{h\to 0} \frac{\cancel{8} + 12h + 6h^2 + h^3 \cancel{-8}}{h} = \lim_{h\to 0} 12 + 6h + h^2$$

$$= 12$$

3. Evaluate the limit, if it exists:

$$\lim_{u\to 2} \frac{\sqrt{4u+1} - 3}{u - 2} = \lim_{u\to 2} \frac{\sqrt{4u+1} - 3}{u-2}\left(\frac{\sqrt{4u+1} + 3}{\sqrt{4u+1} + 3}\right) = \lim_{u\to 2} \frac{(4u+1) - 9}{(u-2)(\sqrt{4u+1} - 3)}$$

$$= \lim_{u\to 2} \frac{4\cancel{(u-2)}}{\cancel{(u-2)}(\sqrt{4u+1} + 3)} = \lim_{u\to 2} \frac{4}{\sqrt{4u+1} + 3} = \frac{4}{\sqrt{9} + 3}$$

$$= \frac{4}{6} = \frac{2}{3}$$

4. Evaluate the limit, if it exists:

$$\lim_{t\to 0}\left(\frac{1}{t\sqrt{1+t}}-\frac{1}{t}\right) = \lim_{t\to 0}\frac{1-\sqrt{1+t}}{t\sqrt{1+t}} = \lim_{t\to 0}\frac{1-\sqrt{1+t}}{t\sqrt{1+t}}\left(\frac{1+\sqrt{1+t}}{1+\sqrt{1+t}}\right)$$

$$= \lim_{t\to 0}\frac{1-(1+t)}{t\sqrt{1+t}\,(1+\sqrt{1+t})} = \lim_{t\to 0}\frac{\cancel{-t}}{\cancel{t}\sqrt{1+t}\,(1+\sqrt{1+t})}$$

$$= \frac{-1}{\sqrt{1}\,(1+\sqrt{1})} = \frac{-1}{2}$$

5. Evaluate the limit, if it exists:

$$\lim_{x\to 3}\frac{\frac{1}{x}-\frac{1}{3}}{x-3} = \lim_{x\to 3}\frac{\left(\frac{3-x}{3x}\right)}{(x-3)} = \lim_{x\to 3}\frac{3-x}{(x-3)(3x)} = \lim_{x\to 3}\frac{-1}{3x} = \frac{-1}{9}$$

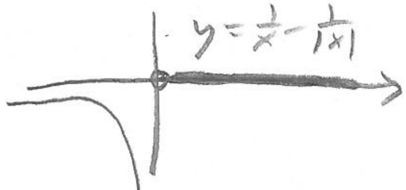
6. Evaluate the limits, if they exist, and otherwise explain why they do not:

(a)

$$\lim_{x\to 0^-}\left(\frac{1}{x}-\frac{1}{|x|}\right) = -\infty$$ since if $x<0$, $\frac{1}{|x|} = -\frac{1}{x}$, so $\frac{1}{x}-\frac{1}{|x|} = \frac{2}{x}$

(b)

$$\lim_{x\to 0^+}\left(\frac{1}{x}-\frac{1}{|x|}\right) = 0$$ since if $x>0$, $\frac{1}{|x|} = \frac{1}{x}$, so $\frac{1}{x}-\frac{1}{|x|} = 0$



7. *Challenge problem.* Consider the following function:

$$f(x) = \begin{cases} 1, & \text{if } x \text{ is rational} \\ 0, & \text{if } x \text{ is irrational} \end{cases}$$

Evaluate the limit $\lim_{x\to 0} f(x)$ if it exists. If it does not exist, explain why.

DNE since there are both rational and irrational numbers arbitrarily close to 0, the function values near $x=0$ jump between 0 & 1 and so don't approach any number.