5. Logarithms – track exponents

$\log 10^7 = 7$

$\log 24 = 1.38 \longrightarrow 10^{1.38} = 24$

$\log 1 = 0 \longrightarrow 10^0 = 1$

$\log 0.01 = -2 \longrightarrow 10^{-2}$

$\log(-3) = ? \longrightarrow 10^{?} = -3$

↑ DNE

$\ln 10^7 = \log_e 10^7 = 16.12 \longrightarrow e^{16.12} = 10^7$

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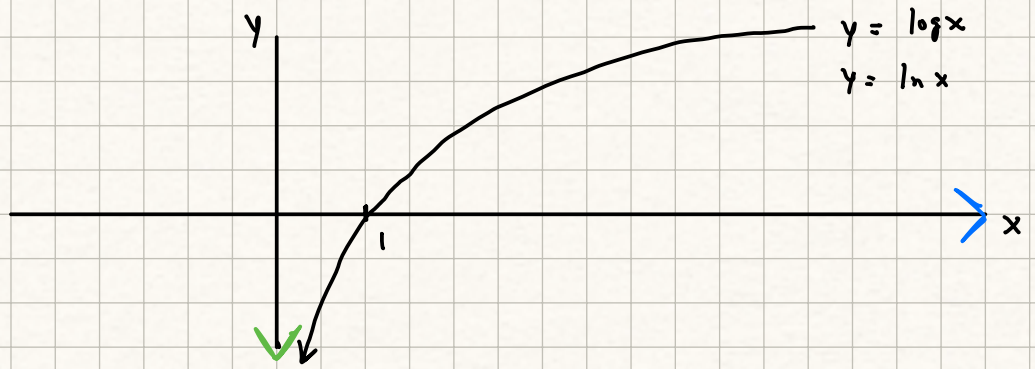
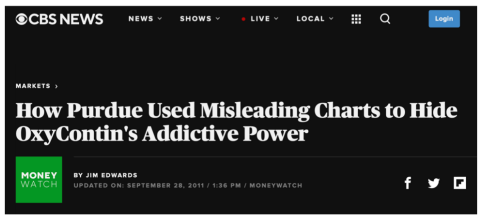


Logs help us process very large and very small numbers:

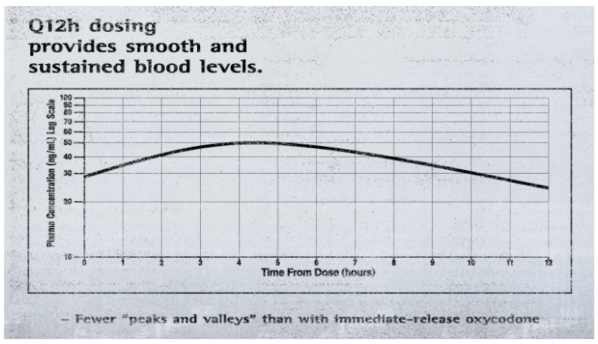
- Scientific Notation (e.g. $10^{77}$)
- OxyContin Scandal




A case filed by the Commonwealth of Kentucky against **Purdue Pharma** sheds new light on the origin of an infamously misleading chart showing that **OxyContin** stays in patients' blood levels over time, when in fact levels of the drug drop off sharply in users, triggering withdrawal symptoms and addiction. The chart was later used by Purdue as a marketing tool to convince doctors that OxyContin was less addictive than it actually was, the case claims.

The suit is unusual because Kentucky isn't just seeking reimbursement for Medicaid payments it made based on misleading marketing for the drug. It's seeking all costs it incurred associated with OxyContin abuse, including millions spent in drug abuse education and prevention, and the "investigation, apprehension, prosecution and incarceration of individuals, who, due to the fraudulently concealed addictive nature of OxyContin, have resorted to criminal means to continue their addiction." Forty people in Pike County, Ky., have died from OxyContin abuse, the case claims. Damages could potentially reach into the billions of dollars.

A version of the chart surfaced in a petition demanding the FDA remove the chart from OxyContin's official labeling. The chart appears to show that OxyContin doses peak quickly and then plateau in the blood stream, providing constant levels of pain relief:

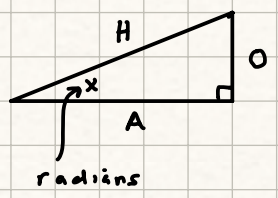



But the chart is in *logarithmic* scale, not *linear* scale. In a log scale, each point on the vertical axis is a multiple of the point below it. On a linear scale -- the scale most people are accustomed to seeing in charts -- the points represent equal intervals. The same data on a linear scale looks like this, showing that OxyContin doses peak quickly and then fall off after a few hours:

The Kentucky case claims that Purdue first developed the chart in a study in the mid 1990s. The chart compared a

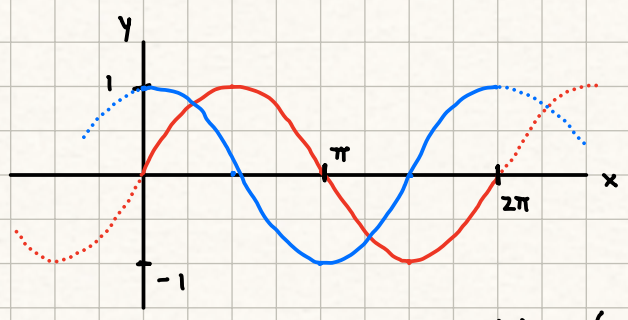
- Richter Scale
- pH
- Decibels
- Statistics

6. **Periodic Functions** – repeating




$\sin x = \frac{O}{H}$ $\cos x = \frac{A}{H}$ $\tan x = \frac{O}{A}$

$\tan x = \frac{\sin x}{\cos x}$




**Note:**

amplitude (max variation from middle)

period = $\frac{2\pi}{k}$

① $y = a \cdot \sin(k \cdot x)$

② All periodic functions are just the sum of sines and cosines of different amplitudes and periods. (Fourier)

# Derivatives

1. **Recall:**

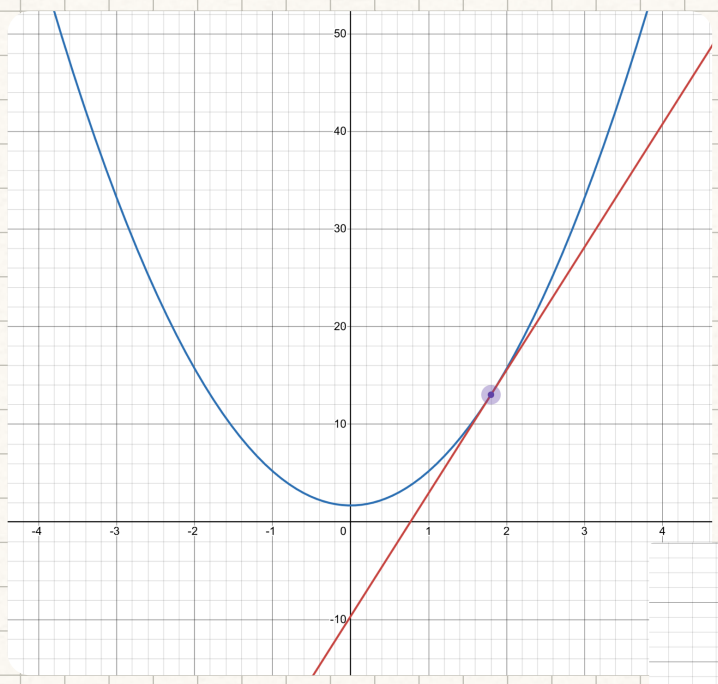
- With a linear function, $y = \boxed{m}x + b$, $m$ represents
  - slope [geometric]
  - rate of change [physical]

- Nonlinear functions have infinitely many different rates of change (slopes):

**Ex:** $y = (3x)x$

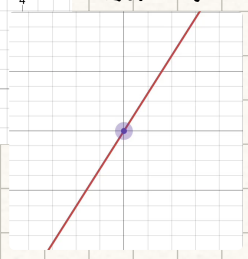
$= 3x^2$ ∪

- **Question:** How do we best think of those rates of change.
  - compute
  - interpret




If we zoom in far enough on a non-linear function, it looks linear.

Zoomed



- **Note:** $\frac{3x^2}{x} \neq 3x$

$f(x) = \frac{3x^2}{x}$ $\quad f(1) = 3,\ f(2) = 6,\ f(0) = \frac{0}{0}$ = undefined

$g(x) = 3x$ $\quad g(1) = 3,\ g(2) = 6,\ g(0) = 0$