The solution to:

$$x \cdot \left(\frac{a}{b}\right)^x = \frac{c}{d}$$

Can be computed via:

$$x = \frac{W\left(\log\left(\frac{a}{b}\right) \cdot \frac{c}{d}\right)}{log\left(\frac{a}{b}\right)}$$

Where W is the Lambert W Function.

In order to approximate this solution, we split the input domain $z = \log\left(\frac{a}{b}\right) \cdot \frac{c}{d}$ into:

$$\underbrace{-\infty \ldots -1/e}\Big|\underbrace{-1/e \ldots 0}\Big|\underbrace{0 \ldots +1/e}\Big|\underbrace{+1/e \ldots 3+1/e}\Big|\underbrace{3+1/e \ldots +\infty}$$

For $z < -1/e$, the value of $W(z)$ is not real.

Respectively, the equation $x \cdot \left(\frac{a}{b}\right)^x = \frac{c}{d}$ has no real solution.

This is because $x \cdot \left(\frac{a}{b}\right)^x \leq \frac{1}{e \cdot \log\left(\frac{b}{a}\right)} < \frac{c}{d}$ for every real value of x.

For $-1/e \leq z \leq +1/e$, you may observe that $x = \frac{W\left(\log\left(\frac{a}{b}\right) \cdot \frac{c}{d}\right)}{log\left(\frac{a}{b}\right)} = \frac{c}{d} \cdot \sum_{n=1}^{\infty} \frac{(-n)^{n-1}}{n!} \cdot \left(\log\left(\frac{a}{b}\right) \cdot \frac{c}{d}\right)^{n-1}$:

- For $-1/e \leq z \leq 0$, which implies that $a \leq b$, we compute $x = \frac{c}{d} \cdot \sum_{n=1}^{\infty} \frac{(+n)^{n-1}}{n!} \cdot \left(\log\left(\frac{b}{a}\right) \cdot \frac{c}{d}\right)^{n-1}$
- For $0 \leq z \leq +1/e$, which implies that $a \geq b$, we compute $x = \frac{c}{d} \cdot \sum_{n=1}^{\infty} \frac{(-n)^{n-1}}{n!} \cdot \left(\log\left(\frac{a}{b}\right) \cdot \frac{c}{d}\right)^{n-1}$

As you can see, when $a = b$, both formulas can be reduced to $x = \frac{c}{d}$.

For $+1/e < z < 3 + 1/e$, we use a lookup table which maps 128 uniformly distributed values of z.

Then, we calculate $W(z')$ as the weighted-average of $W(z_0)$ and $W(z_1)$, where $z_0 \leq z' < z_1$.

For $z \geq 3 + 1/e$, we rely on the fact that $W(z) \approx \log(z) - \log(\log(z)) + \log(\log(z))/\log(z)$.

Of course, z is ultimately restricted by the maximum input supported in our log implementation.