~~N(0, e^v) = res~~

```
wiggins = [N]
volatility = μ
for i in range(0, N):
    v = volatility + θ.(μ - volatility) + N(0, σ)
    volatility = v
    wiggins[i] = N(0, e^v)
```

$P(\text{wiggin} = \text{res}) = \prod_{i=0}^{N-1}$

$P\left(\text{wiggin}[i] = \text{res}[i] \mid \cancel{\text{wiggins}[i-1]}, \theta, \mu, \sigma, \text{volatility}[i-1]\right)$

$-\log(P) = (-1)\left(\sum_{i=0}^{N-1} \log\left(\text{wiggins}[i] = \text{res}[i] \mid \text{volatility}[i-1], \theta, \mu, \sigma\right)\right)$

where volatility $[i-1] = \mu$ if $i = 0$

~~$N(0, e^{c + N(0,c)}) = R$~~

$-\log(P) = (-1)\left(\sum_{i=0}^{N-1} \log\left(\frac{1}{e^{v}\sqrt{2\pi}} \cdot e^{-0.5\left(\frac{\text{res}[i]}{e^{v}}\right)^2}\right)\right)$

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$$\log\left(\frac{1}{e^{v}\sqrt{2\pi}} \cdot e^{-0.5\left(\frac{res[i]}{e^{v}}\right)^2}\right)$$

$$-\log(e^{v}) - \frac{\log 2\pi}{2} - 0.5\left(\frac{res[i]}{e^{v}}\right)^2$$

$$-v - \frac{\log 2\pi}{2} - \frac{1}{2}\left(\frac{res[i]}{e^{v}}\right)^2$$

$$-\log(P) = \sum_{i=0}^{N-1}\left(v + \frac{\log 2\pi}{2} + \frac{1}{2}\left(\frac{-res[i]}{e^{v}}\right)^2\right)$$

where $v = vol[i-1] + \theta(\mu - vol[i-1]) + N(0,\sigma)$

$$-\frac{\partial \log(P)}{\partial \theta}$$

$$= \frac{\partial \cdot \sum_{i=0}^{N-1}\left(v + \frac{\log 2\pi}{2} + \frac{1}{2}\left(\frac{res[i]}{e^{v}}\right)^2\right)}{\partial \theta}$$

$$= \sum_{i=0}^{N-1}\left(\frac{\partial v}{\partial \theta} + \frac{1}{2}\, res[i]^2 \frac{\partial e^{-2v}}{\partial \theta}\right)$$

$$= \sum_{i=0}^{N-1}\left(\frac{\partial v}{\partial \theta} - \left(\frac{res[i]}{e^{v}}\right)^2 \cdot \frac{\partial v}{\partial \theta}\right)$$

$$= \sum_{i=0}^{N-1}\left(\frac{\partial v}{\partial \theta}\left(1 - \left(\frac{res[i]}{e^{v}}\right)^2\right)\right)$$

$$= \sum_{i=0}^{N-1} \frac{\partial v}{\partial \theta} \cdot \left(1 - \left(\frac{res[i]}{e^{v}}\right)^2\right)$$

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$\frac{\partial e^{-2u}}{\partial v} = -2$

$\frac{\partial v}{\partial \theta} = (K - \text{volatility}[i])$

$\frac{\partial v}{\partial v} = \theta$

$\frac{\partial v}{\partial \sigma}$ = let r be the number generated by $N(0, \sigma)$
then

$= \frac{\partial N(0,\sigma)}{\partial \sigma}$ at r

$= \dfrac{\partial \frac{1}{\sigma\sqrt{2\pi}} e^{-0.5\left(\frac{r}{\sigma}\right)^2}}{\partial \sigma}$

$= \frac{1}{\sqrt{2\pi}} \cdot \dfrac{\partial \left(\frac{1}{\sigma} \cdot e^{-0.5\left(\frac{r}{\sigma}\right)^2}\right)}{\partial \sigma}$

$= \cdot \left(\frac{-1}{\sqrt{2\pi}}\right)\left(\frac{(\sigma^2 - r^2)\, e^{-0.5\left(\frac{r}{\sigma}\right)^2}}{\sigma^4}\right)$