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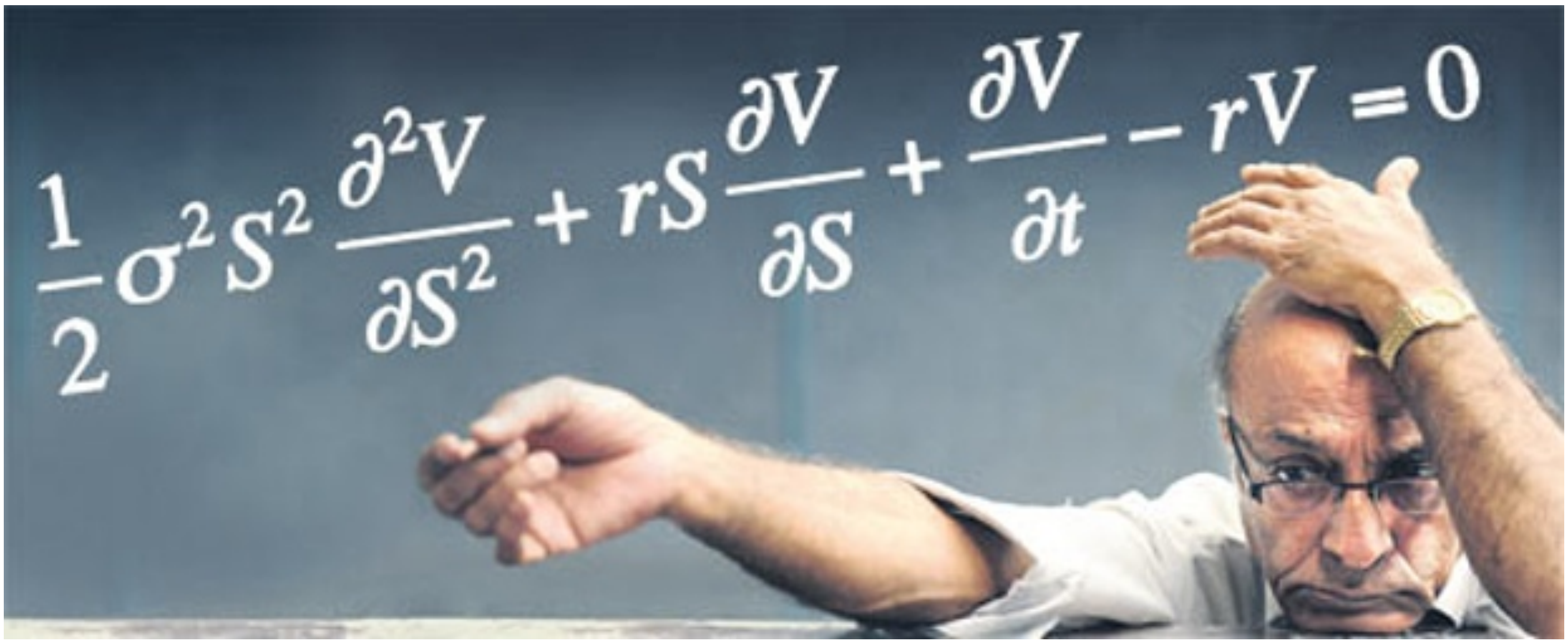
A model for simulation

We need to model stock price behavior now. One of these is Black-Scholes (https://en.wikipedia.org/wiki/Black–Scholes_model):



http://www.theguardian.com/science/2012/feb/12/black-scholes-equation-credit-crunch (http://www.theguardian.com/science/2012/feb/12/black-scholes-equation-credit-crunch)

Here where we assume three things:

- Some volatility or an annualized standard deviation of stock payouts. Call this σ;
- We have a (risk-free) interest rate called r; and
- The price of the asset is geometric Brownian motion, or in other words the log of the random process is a normal distribution.

The long and the short of this is that the *geometric* Brownian motion leads to details here (https://en.wikipedia.org/wiki/Geometric_Brownian_motion#Solving_the_SDE):

$$S_T = S_t e^{(r - \frac{\sigma^2}{2})(T-t) + \sigma\sqrt{T-t}\epsilon}$$

This needs some definition:

- σ is again the volatility, or standard deviation on returns.
- $T - t$ means the time until expiration
- ϵ is the random value. This is the key Brownian component.

To implement this is tricky since we need to go from time t to time T. Here is a function for the whole time history:

```
def St(r, sigma, t):
    W = np.cumsum(np.random.randn(len(t)))
    dt = t[1] - t[0]
    ret = 1.0 * np.exp((r - 0.5 * sigma**2) * t + sigma * np.sqrt(dt) * W)
    return ret
```

with input

```
t = np.linspace(0,1,200)
plt.plot(t, St(1, 0.2, t))
```

Try a few values of σ and r. What do you observe about this *asset pricing scheme

We will now generate many asset prices for the expiration date. Then average them. Then discount the value (due to interest).