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Project 11.

Choose your favorite stock [find its stock ticker symbol WXYZ, usually 1-4 letters].

(a) download the historical data of the stock for the period of 1 year

I chose Disney - DIS.

(b) estimate the average return μ and volatility σ based on (a)

```
In[*]:= data = {101.370003`, 100.800003`, 100.389999`, 100.349998`, 100.239998`, 102.169998`,
   101.209999`, 100.889999`, 100.239998`, 100.150002`, 99.459999`, 101.150002`,
   99.839996`, 99.230003`, 100.330002`, 100.059998`, 99.620003`, 98.760002`, 101.150002`,
   102.480003`, 101.790001`, 99.970001`, 101.68`, 102.07`, 102.440002`, 102.919998`,
   105.040001`, 104.339996`, 103.93`, 104.059998`, 104.07`, 102.889999`, 102.110001`,
   102.199997`, 99.690002`, 99.980003`, 99.470001`, 99.360001`, 100.239998`, 99.940002`,
   101.910004`, 102.470001`, 103.980003`, 104.349998`, 104.330002`, 106.309998`, 108.75`,
   108.849998`, 107.059998`, 106.099998`, 107.150002`, 105.889999`, 106.339996`,
   104.449997`, 104.260002`, 103.959999`, 104.769997`, 104.809998`, 105.330002`,
   104.040001`, 105.339996`, 104.779999`, 106.019997`, 106.029999`, 108.040001`,
   108.25`, 110, 110.199997`, 110.300003`, 110.690002`, 112.129997`, 111.480003`,
   111.089996`, 110.699997`, 111.18`, 113.510002`, 112.620003`, 112.629997`, 113.559998`,
   112.970001`, 112.75`, 114.089996`, 115.940002`, 116.559998`, 113.980003`, 114.160004`,
   112.68`, 112.120003`, 112.75`, 112.849998`, 112.480003`, 112.480003`, 111.989998`,
   112.389999`, 111.940002`, 112, 111.93`, 112.330002`, 112.580002`, 112.449997`,
   111.919998`, 112.019997`, 110.849998`, 109.870003`, 110.260002`, 110.970001`, 110.68`,
   109.599998`, 109.459999`, 110.669998`, 109.260002`, 109.360001`, 109.529999`,
   109.790001`, 111.620003`, 110.400002`, 112.769997`, 113.629997`, 115.209999`,
   116.040001`, 116.940002`, 116.239998`, 117.660004`, 116.910004`, 116.129997`,
   114.779999`, 116.019997`, 116.889999`, 112.860001`, 111.150002`, 112.610001`,
   113.440002`, 116.190002`, 117.129997`, 116.18`, 118.900002`, 118.269997`,
   117.849998`, 111.610001`, 114.160004`, 113.190002`, 113.040001`, 114.760002`,
   114.830002`, 116.099998`, 115.18`, 115.449997`, 116.709999`, 117.050003`, 116,
   118, 116.699997`, 116.849998`, 117.120003`, 117.110001`, 116.190002`, 115.419998`,
   111.870003`, 113.029999`, 112.080002`, 112.550003`, 113.900002`, 116.099998`,
   116.610001`, 115.489998`, 115.739998`, 112.870003`, 114.330002`, 111.980003`,
   111.860001`, 111.970001`, 112.209999`, 113.389999`, 112.199997`, 110.620003`,
   109.449997`, 109.220001`, 107, 104.220001`, 100.349998`, 105.830002`, 106.519997`,
   107.300003`, 109.650002`, 108.970001`, 106.330002`, 109.610001`, 110.559998`,
   111.419998`, 112.669998`, 112.800003`, 112.650002`, 112.419998`, 111.760002`,
   110.910004`, 111.010002`, 111.040001`, 110.599998`, 111.120003`, 110.550003`,
   111.089996`, 110.809998`, 110.900002`, 110.129997`, 111.519997`, 111.300003`,
   111.800003`, 112.660004`, 111.410004`, 110.949997`, 111.510002`, 109.440002`,
   109.199997`, 110.199997`, 110.660004`, 112.589996`, 113.510002`, 113.68`, 114.290001`,
   115.25`, 113.589996`, 113.5`, 112.779999`, 112.839996`, 114.010002`, 114.330002`,
   114, 114.849998`, 114.010002`, 113.809998`, 114.75`, 114.730003`, 114.089996`,
   114.480003`, 114.959999`, 113.120003`, 110, 109.989998`, 108.660004`, 108.230003`,
   107.790001`, 110.139999`, 110.279999`, 110.709999`, 111.029999`, 112.510002`,
   111.959999`, 112.519997`, 114.75`, 115, 114.959999`, 116.860001`, 116.559998`};

In[*]:= Length[data]

Out[*]= 253
```

In[*]:= $\texttt{dat2 = Table}\left[\texttt{Log}\left[\frac{\texttt{data[[k]]}}{\texttt{data[[k - 1]]}}\right], \{\texttt{k, 2, Length[data]}\}\right] \texttt{ // N;}$

```
In[*]:= Mean[dat2]

Out[*]= 0.000554083
```

In[∘]:= `StandardDeviation[dat2]`

Out[∘]= 0.0119835

In[∘]:= `253 Mean[dat2] (* estimate of` $\mu - \frac{1}{2}\sigma^2$ `*)`

Out[∘]= 0.140183

0.1401830087781906
(* estimate of $\mu - \frac{1}{2}\sigma^2$ ~ annual return of 14.0 % *)

In[∘]:= $\sqrt{253}$ `StandardDeviation[dat2] // N (* estimate of` σ `*)`

Out[∘]= 0.190609

0.1906093224148171
(* estimate of σ ~ annual volatility of 19.1 % *)

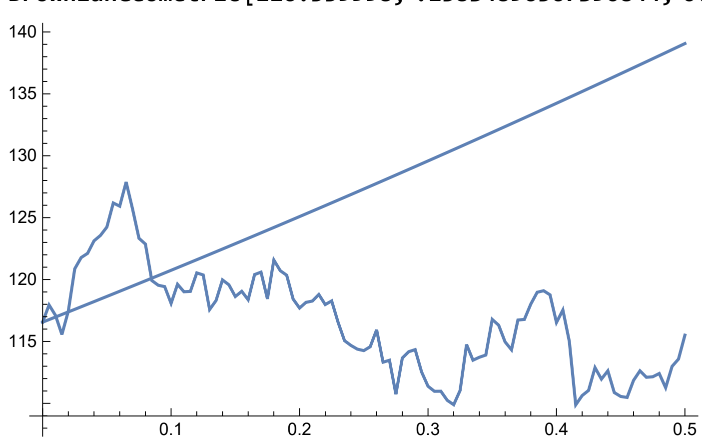
In[∘]:= $0.1401830087781906 + \frac{1}{2}(0.1906093224148171)^2$

Out[∘]= 0.158349

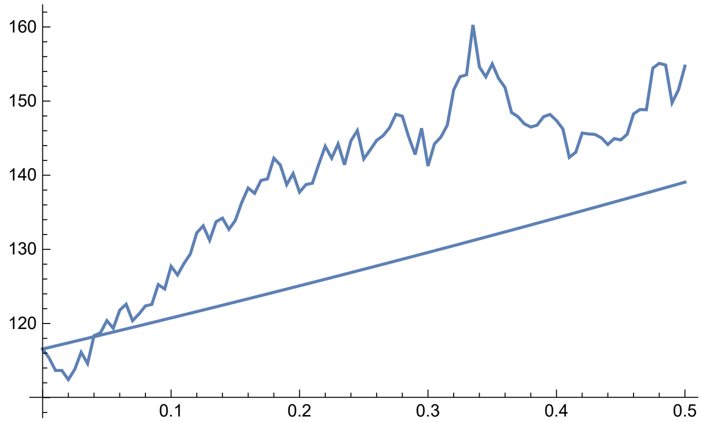
(* estimate of μ ~ annual return of 15 % *)

(c) simulate hypothetical future stock with μ and σ found in (b) for the period of 6 months and show the graphs of 3 different

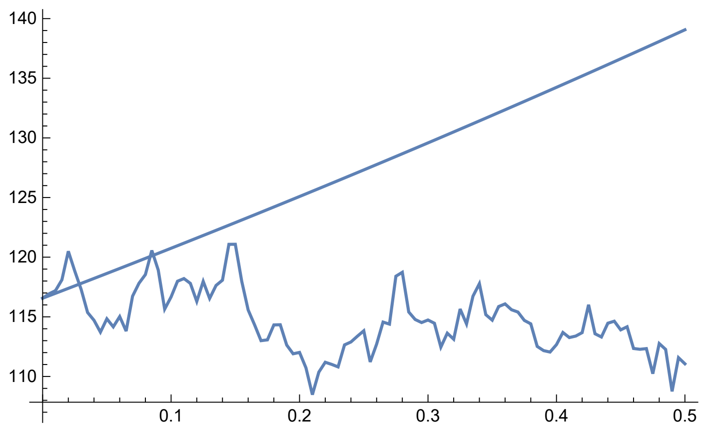
In[∘]:=
```
BrownianGeometric[x0_, μ_, σ_, t_, h_] := Module[{d = √h, m = t/h},
g = Table[Random[NormalDistribution[0, d]], {m}];
sums = FoldList[Plus, 0, g]; Table[X[i * h] = sums[[i + 1]], {i, 0, m}];
geometric = Table[{i * h, x0 * e^(μ *i/m+σ*X[i*h])}, {i, 0, m}];
drift = Table[{i * h, x0 * e^((i/m) * (μ + σ^2/2))}, {i, 0, m}];
g1 = ListPlot[geometric, Joined → True, DisplayFunction → Identity];
g2 = ListPlot[drift, Joined → True, DisplayFunction → Identity];
Show[g1, g2, PlotRange → All, DisplayFunction → $DisplayFunction]];
BrownianGeometric[116.559998, .15834896567390844, 0.1906093224148171, .5, .005]
BrownianGeometric[116.559998, .15834896567390844, 0.1906093224148171, .5, .005]
BrownianGeometric[116.559998, .15834896567390844, 0.1906093224148171, .5, .005]
```

Out[∘]=


Out[ ]=



Out[ ]=



(d) choose a strike price K for Call Option with 6 months expiration time [measured in year units, i.e., months = 6/12]

Choosing strike price K = $115

(e) choose risk free rate r [in decimal percentage, i.e. 2% means to .02] and use the Black-Scholes formula to find the

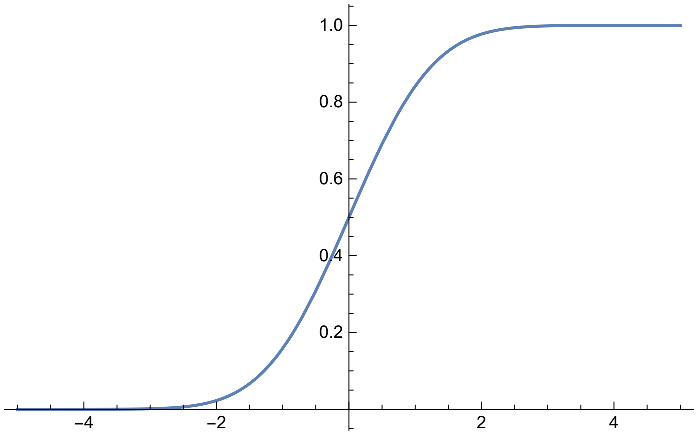
present value of your option. Specify the source and type of r used (e.g, treasury, CD, money market, LIBOR, etc)

Choosing r = 2.46% from US Treasury

In[ ]:=
```
Φ[x_] := CDF[NormalDistribution[0, 1], x];
```

In[∘]:=
```
Plot[Φ[x], {x, -5, 5}]
```

Out[∘]=



In[∘]:=
$$\text{OptionVal}[t\_, T\_, Xt\_, K\_, \sigma\_, r\_] := Xt * \Phi\left[\frac{\left(r + \frac{\sigma^2}{2}\right) * (T - t) + \text{Log}\left[\frac{Xt}{K}\right]}{\sigma\sqrt{T - t}}\right] - K\, e^{-r*(T-t)} * \Phi\left[\frac{\left(r - \frac{\sigma^2}{2}\right) * (T - t) + \text{Log}\left[\frac{Xt}{K}\right]}{\sigma\sqrt{T - t}}\right];$$

In[∘]:= $\text{OptionVal}\left[0, \frac{1}{2}, 116.559998, 115, 0.1906093224148171, .0246\right]$

Out[∘]= 7.77845

(f) compare your option value computed from the Black-Scholes Formula with the option value listed at CBOE
website [your answer should be close to the CBOE trading price]
The option value listed at the CBOE website is 8.8 which is close to my calculated option value.

*For any given Strike Price, generally one chooses the last listed trade [i.e., if the underlying Call Option is
currently/actively traded and falls between the bid- ask price range. If the last trade listing is out of bid-ask range
[i.e., it means that last trade is an old data], then use the average of the bid and ask price as Call Option price.

(g) tweak with σ in the B-S formula [by trial and error] to match the CBOE price exactly.

In[∘]:= $\text{OptionVal}\left[0, \frac{1}{2}, 116.559998, 115, 0.2227, .0246\right]$

Out[∘]= 8.8012

The adjusted volatility is 0.2227 which is slightly higher than the volatility calculated using the past years stock data for Disney.