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Note: Both the questions have been coded in a single file.

Q1.
Starting Stock Price was set to 185.40 (Stock Price as of 30th September 2020)
Strike Price = K = 1.1 * 185.40
The values of **mean** and **variance** from Lab Assignment 7 were used.
μ = 0.0002981060700200034
σ^2 = 0.000496475360718651
Box Muller Method was employed to generate values from the **Normal Distribution**.
Time Interval was set to **0.1**. (30 Days, 300 Time Points)
The following simulating formula was used to simulate the stock prices. (GBM Model)

$$S(t_{i+1}) = S(t_i)\exp\left(\left(\mu - \tfrac{1}{2}\sigma^2\right)(t_{i+1}-t_i) + \sigma\sqrt{t_{i+1}-t_i}\,Z_{i+1}\right)$$

The **Average Price Asian Put Option Payoff** was calculated. (using the formula given in the Assignment)

The process was repeated **1000** times.
The Generated Asian Put Option Payoffs were stored in **array Y**.
The **mean**, **variance**, the **standard variation** and the **95% confidence interval** of the generated Asian Put Option Payoffs was then calculated using NumPy module of Python.

```
Mean of Generated Payoffs = 19.20217585040953
Variance of Generated Payoffs = 139.64339086158176
Standard Variation of Generated Payoffs = 11.81708047114776
Confidence Interval is [18.469745614596007, 19.934606086223056]
```

Q2.
Along with the Average Price Asian Put Option Payoff, **European Put Option Payoff** was also calculated. The European Put Option Payoffs were stored in **array X** (which would act as the **control variable**).

Now, using the below formula, the value of b was estimated.

$$\hat{b}_n = \frac{\sum_{i=1}^{n}(x_i-\bar{x})(Y_i-\bar{Y})}{\sum_{i=1}^{n}(x_i-\bar{x})^2}$$

Using Arrays X, Y and b, the values of the **controlled variable** were calculated as follows:

$$Y_i(b) = Y_i - b(x_i - E(x))$$

(for i^{th} replication)

Using the NumPy module of Python, **mean** and **variance** of the **controlled variable** was found. They are as follows:

```
Mean of the Controlled Variable 19.20217585040953 (Remains the same)
Variance of the Controlled Variable  39.69172584520507 (Is Lesser than original)
```

As expected, the mean of the Controlled Variable is equal to the mean of the Original Variable.
There is a significant decrement in variance (from 139.643 to 39.691).

Results summed up in Tabulated form:

Variable	Mean	Variance	Confidence Interval
Asian Put Option Payoffs	19.202175	139.643390	[18.46974,19.93460]
Controlled Variable	19.202175	39.691725	[18.81168,19.59266]