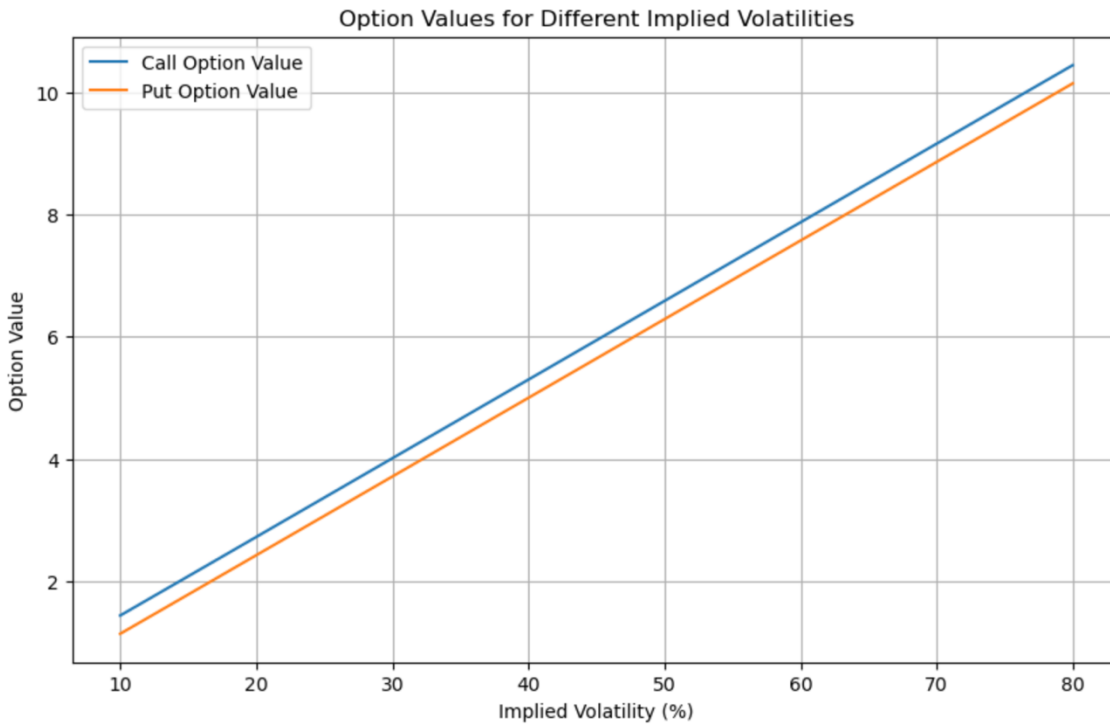


Problem 1

Time to maturity: 0.038356164383561646



The graph shows that both call and put option values increase as implied volatility increases. This is a standard result in option pricing, as higher volatility implies a greater likelihood of the underlying asset moving significantly away from the strike price, increasing the potential payoff of the options.

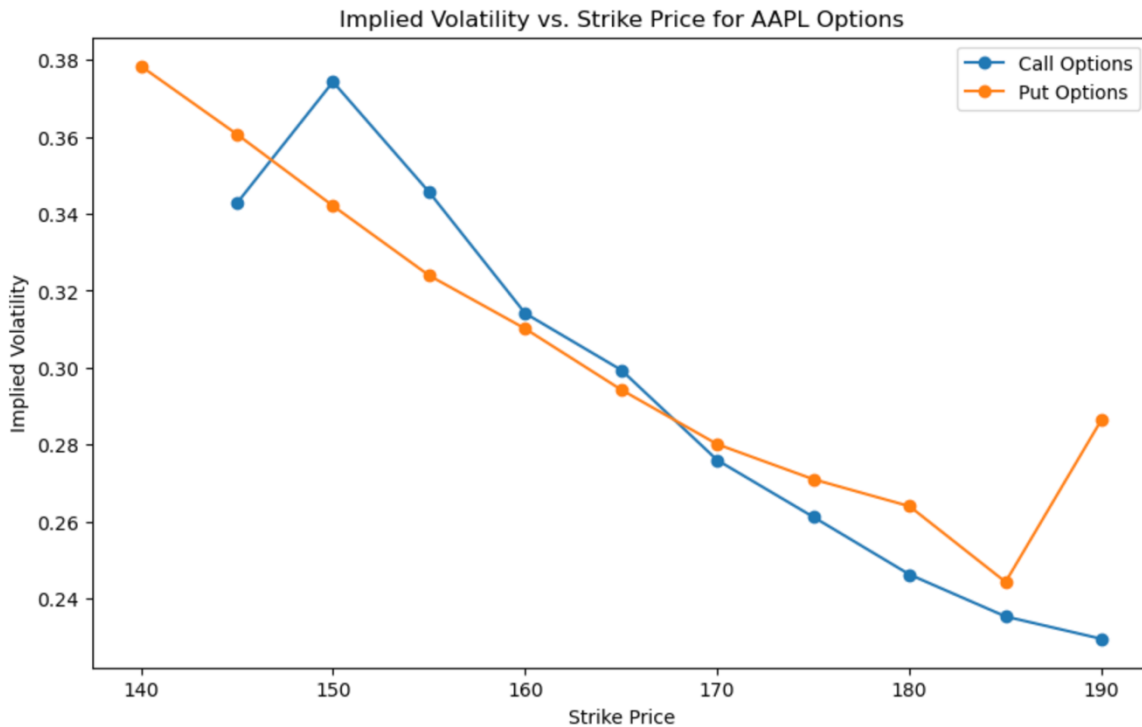
When there is high demand for options, implied volatility generally increases. For example, in times of market uncertainty, investors may buy more options as a hedge, which drives up demand and, consequently, the implied volatility. This increase raises option prices, as shown in the rising values in the graph.

Conversely, if more options are being written, the supply increase can lead to a decrease in implied volatility, reducing option prices.

Problem 2

0	NaN
1	0.342728
2	0.374270
3	0.345630
4	0.314111
5	0.299383
6	0.275944
7	0.261183
8	0.246236
9	0.235327
10	0.229500
11	0.378369
12	0.360649
13	0.342034
14	0.323954
15	0.310123
16	0.294251
17	0.280079
18	0.270984
19	0.263976
20	0.244299
21	0.286510

Name: Implied Volatility, dtype: float64

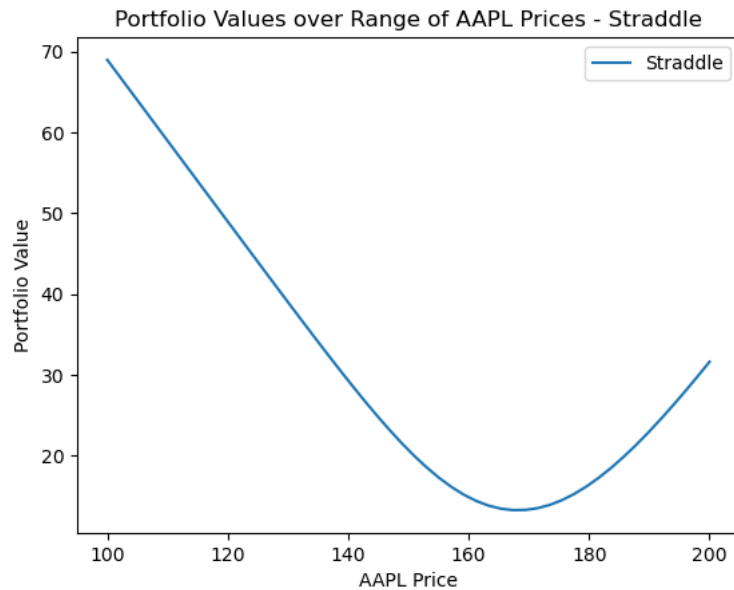


Downward Slope: The implied volatility decreases as the strike price increases for both calls and puts, creating a downward slope.

Higher Implied Volatility for Puts: Investors often use put options to hedge against a potential decline in stock prices. This demand for protection typically increases the implied volatility of out-of-the-money (OTM) put options, especially at lower strike prices.

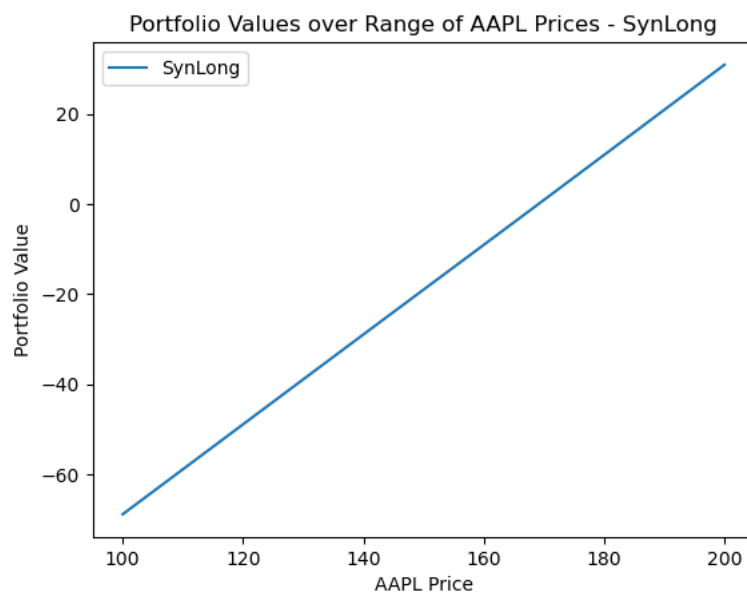
Higher Implied Volatility for Calls: The graph shows that call option values increase as implied volatility increases.

Problem 3



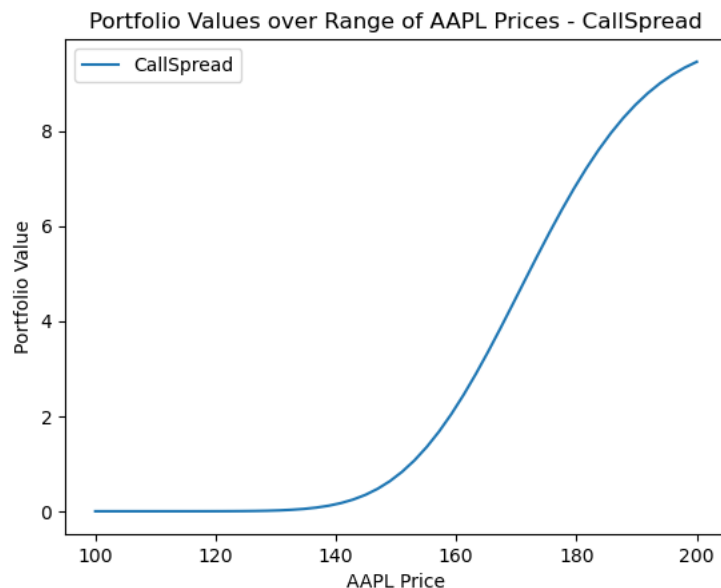
A straddle is an options strategy that involves buying a call option and a put option with the same strike price and expiration date. The shape of the straddle payoff in the graph is V-shaped, indicating that the strategy is profitable if the stock price moves significantly in either direction (up or down) from the strike price, but it incurs a loss if the price remains close to the strike price at expiration.

If the AAPL price moves significantly, the payoff of one of the options (either the call or the put) will increase, compensating for the cost of both options and leading to a profit. The put-call parity essentially tells us that the payoff of this strategy aligns with the difference between the stock price movement and the fixed strike price.



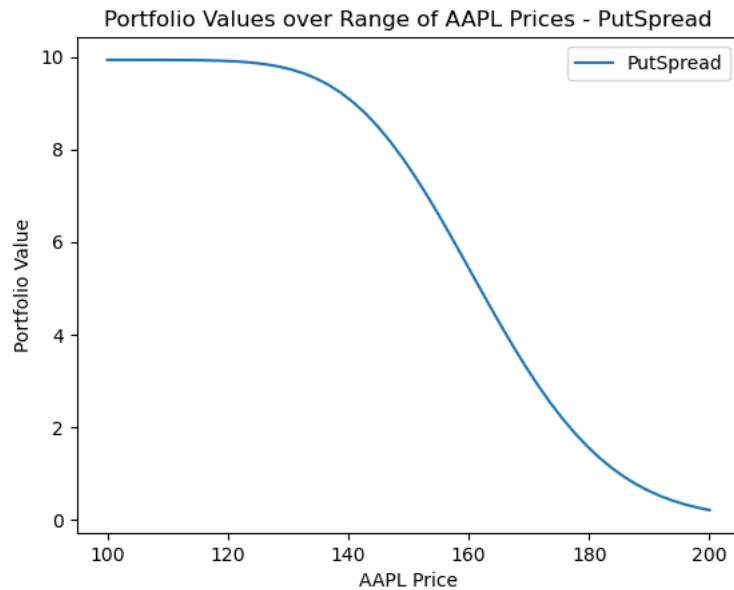
A synthetic long position is created by buying a call and selling a put with the same strike price and expiration date. This position mimics the behavior of holding the underlying asset, as it produces a positive payoff when the asset price increases and a negative payoff when the asset price decreases.

In a synthetic long, the combination of buying a call and selling a put (both at the same strike price) gives a payoff similar to owning the stock. Therefore, when the stock price increases, the portfolio value goes up. When the stock price decreases, the portfolio value declines similarly, which is directly explained by the put-call parity principle



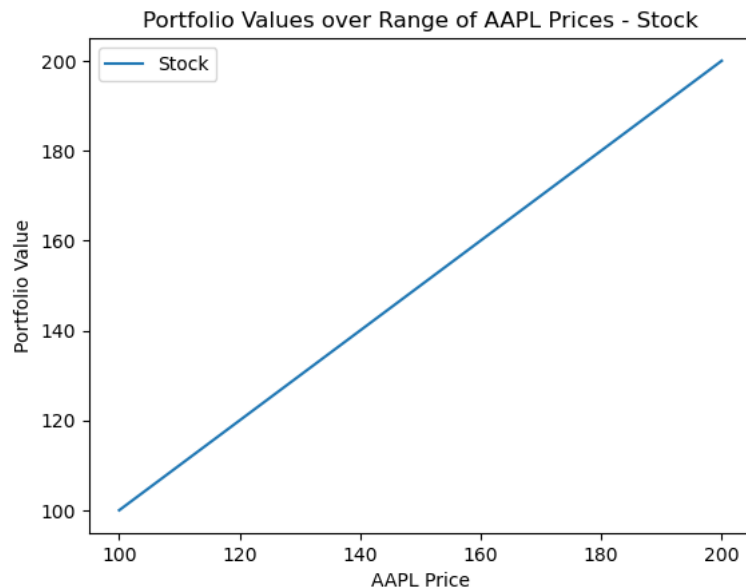
A call spread is created by buying a call option at a lower strike price and selling another call option at a higher strike price. This strategy is designed to profit from moderate increases in the underlying stock's price while limiting both the maximum profit and potential loss.

In this call spread, between the strike prices, the spread value increases as only the bought call is in-the-money. After the higher strike price, both options are in-the-money, and the spread reaches its maximum value, limited by the difference in the two strike prices. Put-call parity helps explain the pricing relationships.



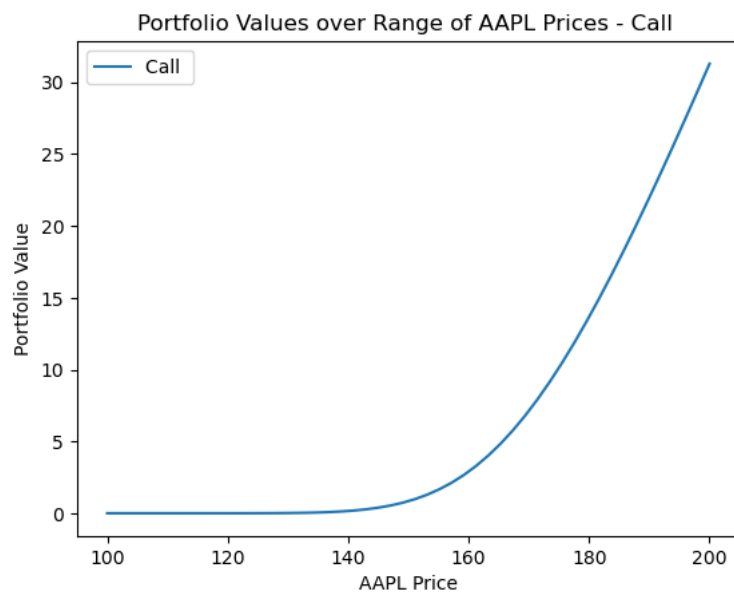
A put spread is constructed by purchasing a put option at a higher strike price and selling a put option at a lower strike price, both with the same expiration date. This strategy is used to profit from a moderate decline in the stock price while capping both the maximum profit and potential loss.

In the put spread, between the two strike prices, the portfolio value rises as only the bought put option is in-the-money. Below the lower strike price, both options are in-the-money, and the spread reaches its maximum possible value, capped by the difference between the strike prices. Put-call parity helps explain the pricing relationships.



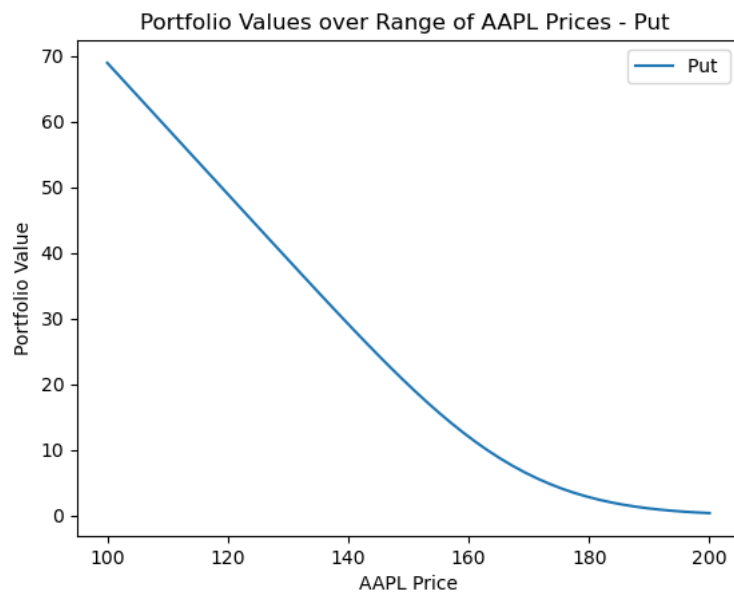
Holding a stock means that the portfolio value changes one-to-one with the price of the stock. There are no caps, limits, or non-linear components in this strategy, as there are with options. This straightforward line indicates that if the stock price of AAPL rises, the portfolio value also rises proportionally, and if the stock price falls, the portfolio value falls accordingly.

In the case of a synthetic stock, one could theoretically construct a position that mimics this linear payoff using a combination of a call and put with the same strike price.



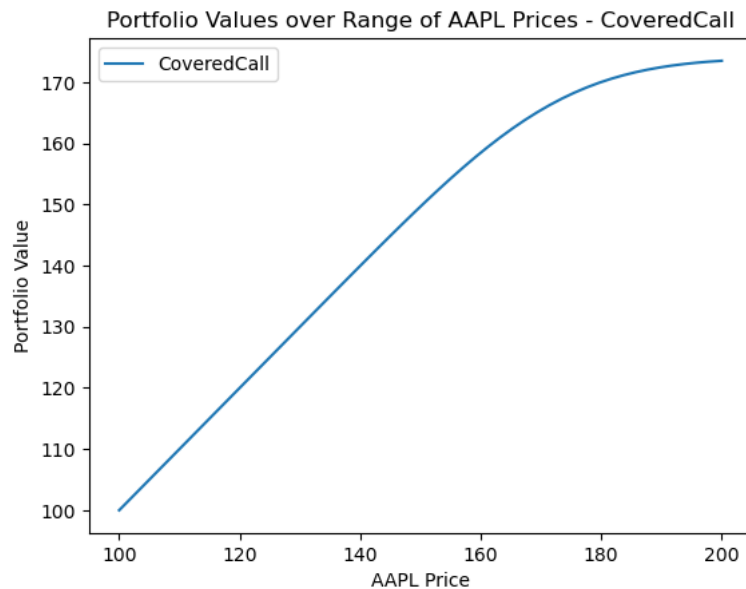
A call option gives the holder the right, but not the obligation, to buy the stock at a specified strike price before expiration.

The put-call parity helps explain that the call option's value increases as the stock price rises, especially as it goes beyond the strike price.



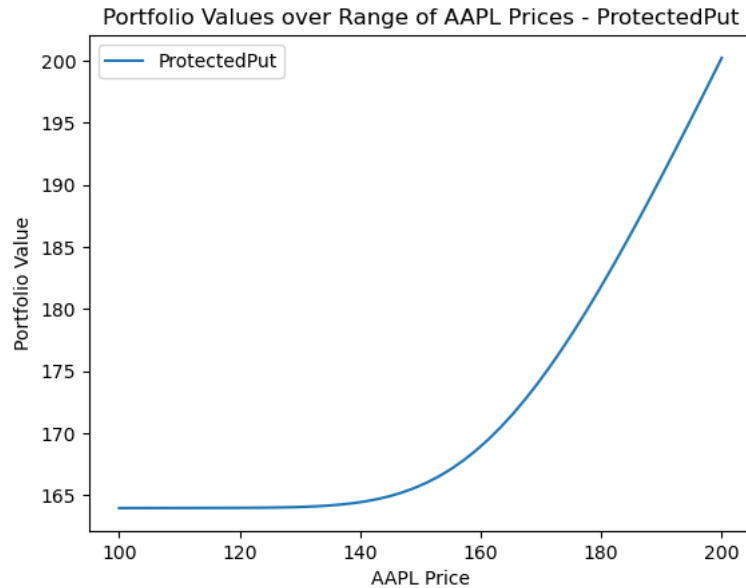
A put option gives the holder the right, but not the obligation, to sell the stock at a specified strike price before expiration.

For a long put, as the stock price falls, the put option's value increases, providing the holder with downside protection against stock price drops. Put-call parity helps explain the pricing relationships.



A covered call strategy involves holding a long position in the stock while simultaneously selling a call option on that stock with the same expiration date. The purpose of this strategy is to generate additional income from the option premium while holding the stock, though it also caps the potential upside.

In the covered call strategy, the long stock position allows the portfolio value to increase as the stock price rises. The sold call limits the potential upside, as gains beyond the strike price are capped. The premium received from selling the call provides some initial income, offsetting potential losses if the stock price falls. Put-call parity helps explain the pricing relationships.



A protected put strategy involves holding a long position in a stock and buying a put option on that stock. This approach provides downside protection while allowing the investor to benefit from stock price increases.

In the protected put strategy, the long stock position provides upward exposure, allowing gains as the stock price increases. The purchased put creates a “floor” for the portfolio value, as it gains value if the stock price falls below the strike price, offsetting losses from the stock. Put-call parity helps explain the pricing relationships.

	Portfolio	Mean	VaR	ES
0	Straddle	0.026828	0.152779	0.198406
1	SynLong	-2.611656	14.028682	16.929067
2	CallSpread	-0.151310	0.775118	0.933590
3	PutSpread	0.218425	0.685200	0.914758
4	Stock	-0.015514	0.085666	0.103488
5	Call	-0.165295	0.868317	1.046914
6	Put	0.251699	0.885189	1.174004
7	CoveredCall	-0.010950	0.061952	0.074909
8	ProtectedPut	-0.008321	0.045542	0.054997

1. Mean:

- Positive mean values (e.g., for Straddle, PutSpread, and Put) suggest that, on average, these portfolios yielded gains during the simulation.
- Negative mean values (e.g., for SynLong, CallSpread, Stock, Call, and ProtectedPut) indicate that these portfolios had average losses over the period.
- The large negative mean for SynLong suggests this portfolio faced substantial losses on average, possibly due to exposure to market movements or option characteristics.

2. VaR (Value at Risk):

- SynLong has the highest VaR, indicating that this portfolio type could experience the most substantial losses under adverse conditions. This aligns with its large negative mean return, suggesting that it may be a riskier portfolio with high exposure to downside risk.
- Other portfolios, such as Put and Call, have moderately high VaR values, reflecting the inherent risk in directional option positions.
- ProtectedPut and CoveredCall have relatively low VaR values, suggesting lower risk exposure, possibly due to their conservative structure, which typically combines stock with protective options.

3. ES (Expected Shortfall):

- Similar to VaR, SynLong has the highest ES, showing that, in extreme market downturns, this portfolio could incur significantly high losses.
- Other portfolios with higher ES values include Put and Call, which reflects the higher downside risk of options, particularly when there is no offsetting strategy.
- Lower ES values for ProtectedPut and CoveredCall suggest these portfolios would likely perform better in adverse conditions, confirming their more conservative risk profiles.