Question 1.1

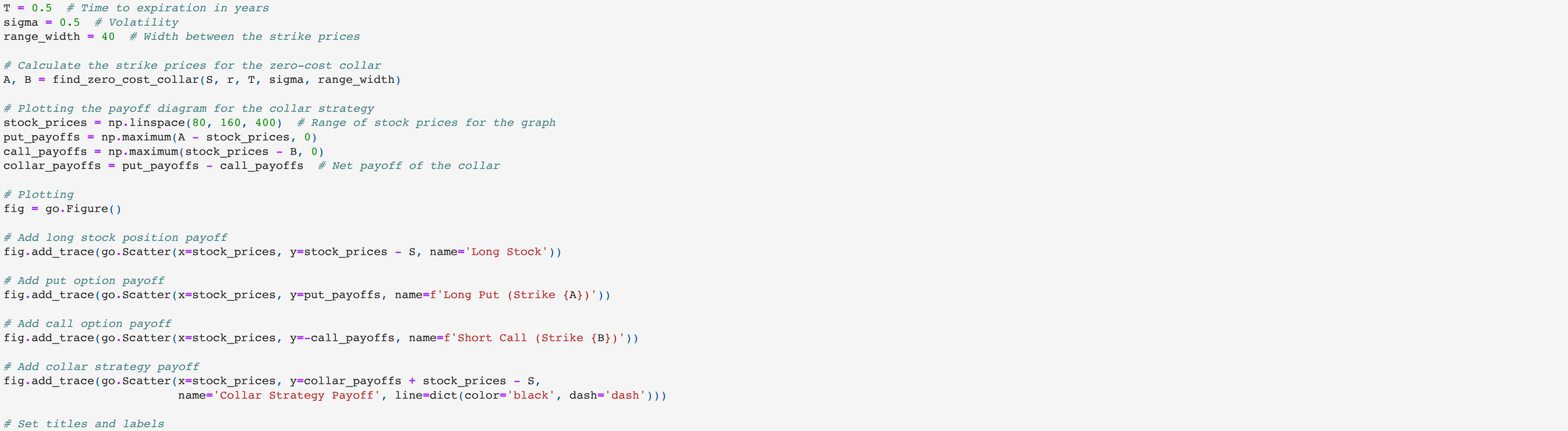
The collar strategy involves buying an OTM put and selling an OTM call, while holding a long position in the underlying.

In [2]:
```
import numpy as np
import plotly.graph_objects as go
from scipy.stats import norm
from scipy.optimize import brentq
```

In [3]:
```
def bs_price(S, K, r, T, sigma, option_type):
    d1 = (np.log(S / K) + (r + 0.5 * sigma ** 2) * T) / (sigma * np.sqrt(T))
    d2 = d1 - sigma * np.sqrt(T)

    if option_type == 'call':
        return S * norm.cdf(d1) - K * np.exp(-r * T) * norm.cdf(d2)
    else:  # 'put'
        return K * np.exp(-r * T) * norm.cdf(-d2) - S * norm.cdf(-d1)
```

In [4]:
```
S = 120
K = (100, 140)
T = 1
r = 0.05
sigma = 0.5
```

In [5]:
```
# Define the function to find the zero-cost collar strike prices
def find_zero_cost_collar(S, r, T, sigma, range_width):
    def cost_difference(K):
        put_price = bs_price(S, K, r, T, sigma, 'put')
        call_price = bs_price(S, K + range_width, r, T, sigma, 'call')
        return call_price - put_price

    A = brentq(cost_difference, S - range_width, S)
    B = A + range_width
    return round(A, 2), round(B, 2)


# Parameters from the problem
S = 120  # Current stock price
r = 0.05  # Risk-free rate
T = 0.5  # Time to expiration in years
sigma = 0.5  # Volatility
range_width = 40  # Width between the strike prices

# Calculate the strike prices for the zero-cost collar
A, B = find_zero_cost_collar(S, r, T, sigma, range_width)

# Plotting the payoff diagram for the collar strategy
stock_prices = np.linspace(80, 160, 400)  # Range of stock prices for the graph
put_payoffs = np.maximum(A - stock_prices, 0)
call_payoffs = np.maximum(stock_prices - B, 0)
collar_payoffs = put_payoffs - call_payoffs  # Net payoff of the collar

# Plotting
fig = go.Figure()

# Add long stock position payoff
fig.add_trace(go.Scatter(x=stock_prices, y=stock_prices - S, name='Long Stock'))

# Add put option payoff
fig.add_trace(go.Scatter(x=stock_prices, y=put_payoffs, name=f'Long Put (Strike {A})'))

# Add call option payoff
fig.add_trace(go.Scatter(x=stock_prices, y=-call_payoffs, name=f'Short Call (Strike {B})'))

# Add collar strategy payoff
fig.add_trace(go.Scatter(x=stock_prices, y=collar_payoffs + stock_prices - S,
                         name='Collar Strategy Payoff', line=dict(color='black', dash='dash')))

# Set titles and labels
fig.update_layout(
    title='Payoff Diagram for a Collar Strategy',
    xaxis_title='Stock Price at Expiration',
    yaxis_title='Payoff',
    legend_title='Strategy Components'
)

# Show the graph
fig.show()
```



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