Final_project

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Question 1: (50 points)

1.1

Download the historical prices for the ticker "NFLX" from 2025-01-01 until now

```
library(quantmod)
```

```
## Loading required package: xts
```

```
## Loading required package: zoo
```

```
##
## Attaching package: 'zoo'
```

```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```
## Loading required package: TTR
```

```
## Registered S3 method overwritten by 'quantmod':
##   method            from
##   as.zoo.data.frame zoo
```

```
getSymbols("NFLX",src = "yahoo",from="2025-01-01")
```

```
## [1] "NFLX"
```

```
head(NFLX)
```

```
##            NFLX.Open NFLX.High NFLX.Low NFLX.Close NFLX.Volume NFLX.Adjusted
## 2025-01-02    89.550    89.858   87.700     88.673    23123000        88.673
## 2025-01-03    89.313    89.883   87.989     88.105    29673000        88.105
## 2025-01-06    88.876    89.283   87.169     88.179    34577000        88.179
## 2025-01-07    87.938    88.800   86.911     87.919    26498000        87.919
## 2025-01-08    88.000    88.622   87.300     87.500    23479000        87.500
## 2025-01-10    86.640    86.641   83.440     83.769    48033000        83.769
```

1.2

Calculate the daily log returns for NFLX using the adjusted close prices

```
logRes <- na.omit(diff(log(Ad(NFLX))))
head(logRes)
```

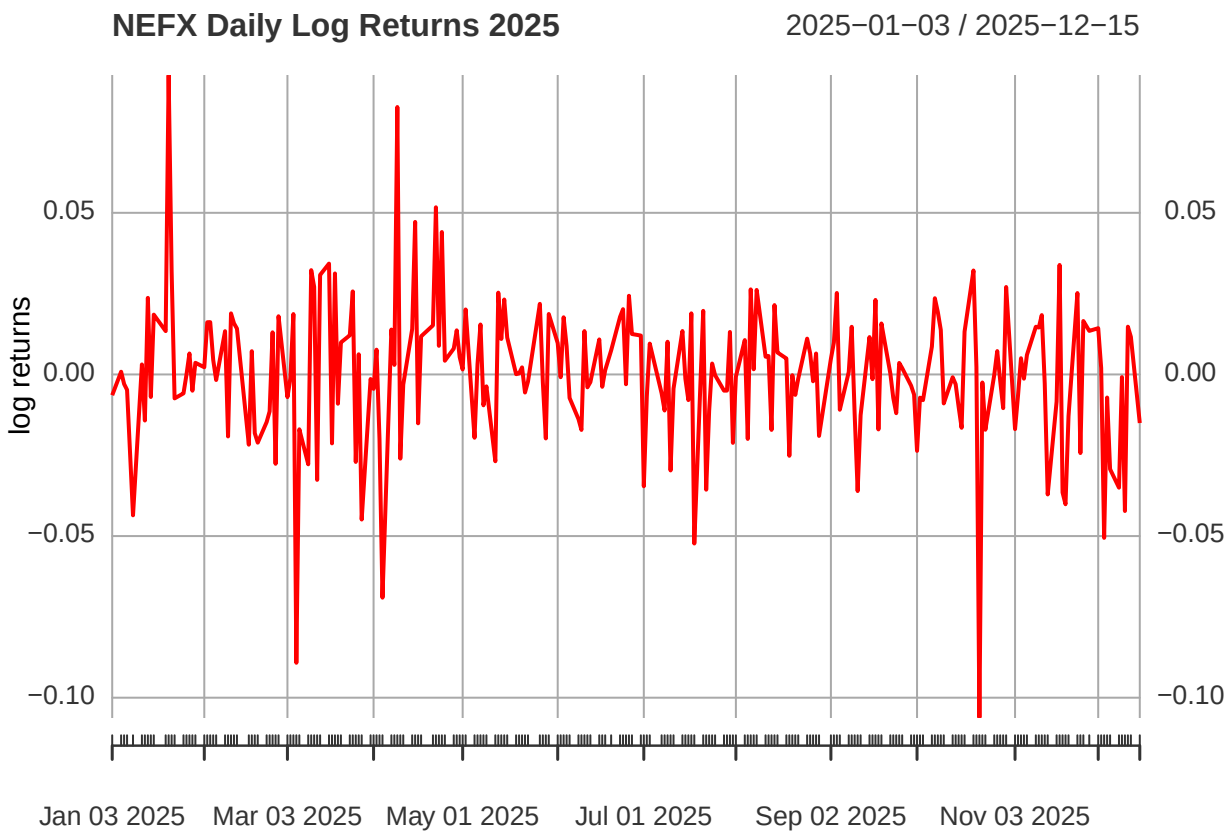
```
##            NFLX.Adjusted
## 2025-01-03  -0.006426084
```

```
## 2025-01-06   0.000839526
## 2025-01-07  -0.002952928
## 2025-01-08  -0.004777128
## 2025-01-10  -0.043575816
## 2025-01-13   0.003098992
```

1.3

plot the daily log returns in red line

```r
plot(logRes,main= "NEFX Daily Log Returns 2025",col="red",ylab="log returns")
```



Question 2

2.1

Calculate the skewness and kurtosis of the NFLX daily log return from Question 1, for both adjusted and unadjusted ones. (See page 21 and 23 of L6 and the corresponding HW problems)

```r
sampleSkewness <- function(x, adjusted = TRUE) {
  n <- length(x)
  xbar <- mean(x)
  # second and third central moments
  m2 <- mean((x - xbar)^2)
  m3 <- mean((x - xbar)^3)
  # unadjusted skewness
  skewUnadj <- m3 / (m2^(3/2))
```

```
  if (adjusted == TRUE) {
    # adjusted skewness
    skewAdj <- sqrt(n * (n - 1)) / (n - 2) * skewUnadj
    return(skewAdj)
  } else {
    return(skewUnadj)
  }
}
sampleKurtosis <- function(x, adjusted = TRUE) {
  n <- length(x)
  xbar <- mean(x)
  # second and fourth central moments
  m2 <- mean((x - xbar)^2)
  m4 <- mean((x - xbar)^4)
  # unadjusted kurtosis
  kurtUnadj <- m4 / (m2^2)
  if (adjusted == TRUE) {
    # adjusted kurtosis
    kurtAdj <- ((n - 1) / ((n - 2) * (n - 3))) *
               ((n + 1) * kurtUnadj - 3 * (n - 1)) + 3
    return(kurtAdj)
  }
  else{
    return(kurtUnadj)
    }
  }

# Stats for Adjusted
skewAdj <- sampleSkewness(logRes,adjusted = T)
kurtAdj <- sampleKurtosis(logRes,adjusted = T)

# Stats for Unadjusted
skewUadj <- sampleSkewness(logRes,adjusted = F)
kurtUadj <- sampleKurtosis(logRes,adjusted = F)
```

2.2

Report the results in 2.1 using a 2×2 table (either data frame or matrix) such that: The column names are "SPY.skewness" and "SPY.kurtosis". And the row names are "Unadjusted" and "Adjusted".

```
#creating a resultant matrix
resMat <-  matrix(c(skewAdj,kurtAdj,skewUadj,kurtUadj),nrow = 2, byrow = T)
rownames(resMat) <- c( "Adjusted","Unadjusted")
colnames(resMat) <- c("SPY.skewness", "SPY.kurtosis")
print(resMat)
```

```
##            SPY.skewness SPY.kurtosis
## Adjusted     -0.4923509     7.640418
## Unadjusted   -0.4892424     7.518397
```

Question 3

3.1

Download options prices for ticker "NFLX" for all expiration dates.

```
nflxOptns <- getOptionChain("NFLX")
names(nflxOptns)
```

```
## [1] "calls" "puts"
```

```
head(nflxOptns$calls)
```

```
##             ContractID ConractSize Currency Expiration Strike  Last        Chg
## 1 NFLX251219C00001000     REGULAR      USD 2025-12-19      1 92.95  0.2299957
## 2 NFLX251219C00002000     REGULAR      USD 2025-12-19      2 92.54  1.1500015
## 3 NFLX251219C00003000     REGULAR      USD 2025-12-19      3 91.52  1.0499954
## 4 NFLX251219C00004000     REGULAR      USD 2025-12-19      4 90.10 -0.4899979
## 5 NFLX251219C00005000     REGULAR      USD 2025-12-19      5 89.12 -0.5400009
## 6 NFLX251219C00006000     REGULAR      USD 2025-12-19      6 87.81  0.5999985
##       ChgPct   Bid   Ask Vol    OI       LastTradeTime       IV  ITM
## 1  0.2480541 89.25 97.75   6 58723 2025-12-16 13:00:36  0.00000 TRUE
## 2  1.2583450 88.25 96.75  59  7255 2025-12-16 12:06:13  0.00000 TRUE
## 3  1.1606007 87.30 95.75   8  2147 2025-12-16 12:06:30  0.00000 TRUE
## 4 -0.5408962 86.30 94.75  27    37 2025-12-16 14:18:03  0.00000 TRUE
## 5 -0.6022763 85.30 93.75  22  3551 2025-12-16 14:18:03 44.00000 TRUE
## 6  0.6879928 84.00 93.00   9    32 2025-12-16 09:30:01 38.35938 TRUE
```

3.2

For calls and puts of each expiration date, add a column of "Price", which is the average of "Bid" and "Ask"

```
nflxOptns$calls$Price <- (nflxOptns$calls$Bid+nflxOptns$calls$Ask)/2
nflxOptns$puts$Price <- (nflxOptns$puts$Bid+nflxOptns$puts$Ask)/2
head(nflxOptns$calls)
```

```
##             ContractID ConractSize Currency Expiration Strike  Last        Chg
## 1 NFLX251219C00001000     REGULAR      USD 2025-12-19      1 92.95  0.2299957
## 2 NFLX251219C00002000     REGULAR      USD 2025-12-19      2 92.54  1.1500015
## 3 NFLX251219C00003000     REGULAR      USD 2025-12-19      3 91.52  1.0499954
## 4 NFLX251219C00004000     REGULAR      USD 2025-12-19      4 90.10 -0.4899979
## 5 NFLX251219C00005000     REGULAR      USD 2025-12-19      5 89.12 -0.5400009
## 6 NFLX251219C00006000     REGULAR      USD 2025-12-19      6 87.81  0.5999985
##       ChgPct   Bid   Ask Vol    OI       LastTradeTime       IV  ITM  Price
## 1  0.2480541 89.25 97.75   6 58723 2025-12-16 13:00:36  0.00000 TRUE 93.500
## 2  1.2583450 88.25 96.75  59  7255 2025-12-16 12:06:13  0.00000 TRUE 92.500
## 3  1.1606007 87.30 95.75   8  2147 2025-12-16 12:06:30  0.00000 TRUE 91.525
## 4 -0.5408962 86.30 94.75  27    37 2025-12-16 14:18:03  0.00000 TRUE 90.525
## 5 -0.6022763 85.30 93.75  22  3551 2025-12-16 14:18:03 44.00000 TRUE 89.525
## 6  0.6879928 84.00 93.00   9    32 2025-12-16 09:30:01 38.35938 TRUE 88.500
```

```
head(nflxOptns$puts)
```

```
##             ContractID ConractSize Currency Expiration Strike Last Chg ChgPct
## 1 NFLX251219P00001000     REGULAR      USD 2025-12-19      1 0.01   0      0
## 2 NFLX251219P00004000     REGULAR      USD 2025-12-19      4 0.04   0      0
## 3 NFLX251219P00010000     REGULAR      USD 2025-12-19     10 0.00   0    -50
```

```
## 4 NFLX251219P00014000     REGULAR      USD 2025-12-19     14 0.01   0      0
## 5 NFLX251219P00015000     REGULAR      USD 2025-12-19     15 0.01   0      0
## 6 NFLX251219P00016000     REGULAR      USD 2025-12-19     16 0.06   0      0
##   Bid  Ask Vol   OI       LastTradeTime        IV   ITM Price
## 1   0 0.01  NA 9781 2025-11-19 15:29:43 17.000005 FALSE 0.005
## 2  NA   NA  NA   NA 2025-12-15 00:01:01  0.000000 FALSE    NA
## 3   0 0.01   1 2970 2025-11-07 11:37:22  7.875000 FALSE 0.005
## 4   0 0.01  NA 1423 2025-11-17 10:50:53  6.750002 FALSE 0.005
## 5   0 0.01   1 7252 2025-12-15 10:16:40  6.500002 FALSE 0.005
## 6   0 0.04   1 3089 2025-12-15 10:16:40  7.062501 FALSE 0.020
```

3.3

For calls and puts of each expiration date, add a column of "ImpliedVol", which is the implied volatility of the corresponding options calculated from root finding methods. (Method is not limited, but you may need to handle the problem when price difference has the same sign on the end of interval)

```r
# Creating Bisection Call and Put
bs.call <- function(S0, K, T1, sigma, r){
  d1 <- (log(S0/K) + (r + 0.5*sigma^2)*T1)/(sigma*sqrt(T1))
  d2 <- d1 - sigma*sqrt(T1)
  S0*pnorm(d1) - exp(-r*T1)*K*pnorm(d2)
}

bs.put <- function(S0, K, T1, sigma, r){
  bs.call(S0, K, T1, sigma, r) - S0 + K*exp(-r*T1)
}
#bisection modified function
bisection.new <- function(f, a, b, tol = 0.001, N.max = 100){

  f.a <- f(a)
  f.b <- f(b)

  # Modified part (Lecture 9)
  if (is.na(f.a * f.b) || f.a * f.b > 0) {
    return(NA)
  } else if (f.a == 0) {
    return(a)
  } else if (f.b == 0) {
    return(b)
  }

  for (n in 1:N.max) {
    c <- (a + b) / 2
    f.c <- f(c)

    if (f.c == 0 || abs(b - a) < tol) {
      break
    }

    if (f.a * f.c < 0) {
      b <- c
      f.b <- f.c
    } else {
      a <- c
```

```
      f.a <- f.c
    }
  }
  return(c)
}


# Implied Volume
implied.vol <- function(type, S0, K, T1, r, price){

  price.diff <- function(sigma){
    if(type == "call"){
      bs.call(S0, K, T1, sigma, r) - price
    } else {
      bs.put(S0, K, T1, sigma, r) - price
    }
  }
  # handling failure if there is no sign change
  if (is.na(price.diff(0.01) * price.diff(5)) ||
      price.diff(0.01) * price.diff(5) > 0) {
    return(NA)
  }
  bisection.new(price.diff, 0.01, 5)
}

# Spot price of NFLX
S0 <- getQuote("NFLX")$Last
# Risk-free rate (constant, acceptable)
r <- 0.05
tCall <- as.numeric(
  as.Date(nflxOptns$calls$Expiration) - Sys.Date()
) / 365

tPut <- as.numeric(
  as.Date(nflxOptns$puts$Expiration) - Sys.Date()
) / 365

nflxOptns$calls$ImpliedVol <- mapply(implied.vol,
                                     type = "call",
                                     S0 = S0,
                                     K  = nflxOptns$calls$Strike,
                                     T1 = tCall,
                                     r  = r,
                                     price = nflxOptns$calls$Price
                                     )

nflxOptns$puts$ImpliedVol <- mapply(implied.vol,
                                    type = "put",
                                    S0 = S0,
                                    K = nflxOptns$puts$Strike,
                                    T1 = tPut,
                                    r  = r,
                                    price = nflxOptns$puts$Price
```

```
                                    )

#checking if Implied Volatility is added
head(nflxOptns$calls)
```

```
##            ContractID ConractSize Currency Expiration Strike  Last        Chg
## 1 NFLX251219C00001000     REGULAR      USD 2025-12-19      1 92.95  0.2299957
## 2 NFLX251219C00002000     REGULAR      USD 2025-12-19      2 92.54  1.1500015
## 3 NFLX251219C00003000     REGULAR      USD 2025-12-19      3 91.52  1.0499954
## 4 NFLX251219C00004000     REGULAR      USD 2025-12-19      4 90.10 -0.4899979
## 5 NFLX251219C00005000     REGULAR      USD 2025-12-19      5 89.12 -0.5400009
## 6 NFLX251219C00006000     REGULAR      USD 2025-12-19      6 87.81  0.5999985
##       ChgPct   Bid   Ask Vol    OI       LastTradeTime       IV  ITM  Price
## 1  0.2480541 89.25 97.75   6 58723 2025-12-16 13:00:36  0.00000 TRUE 93.500
## 2  1.2583450 88.25 96.75  59  7255 2025-12-16 12:06:13  0.00000 TRUE 92.500
## 3  1.1606007 87.30 95.75   8  2147 2025-12-16 12:06:30  0.00000 TRUE 91.525
## 4 -0.5408962 86.30 94.75  27    37 2025-12-16 14:18:03  0.00000 TRUE 90.525
## 5 -0.6022763 85.30 93.75  22  3551 2025-12-16 14:18:03 44.00000 TRUE 89.525
## 6  0.6879928 84.00 93.00   9    32 2025-12-16 09:30:01 38.35938 TRUE 88.500
##   ImpliedVol
## 1         NA
## 2         NA
## 3         NA
## 4         NA
## 5         NA
## 6         NA
```

```
head(nflxOptns$puts)
```

```
##            ContractID ConractSize Currency Expiration Strike Last Chg ChgPct
## 1 NFLX251219P00001000     REGULAR      USD 2025-12-19      1 0.01   0      0
## 2 NFLX251219P00004000     REGULAR      USD 2025-12-19      4 0.04   0      0
## 3 NFLX251219P00010000     REGULAR      USD 2025-12-19     10 0.00   0    -50
## 4 NFLX251219P00014000     REGULAR      USD 2025-12-19     14 0.01   0      0
## 5 NFLX251219P00015000     REGULAR      USD 2025-12-19     15 0.01   0      0
## 6 NFLX251219P00016000     REGULAR      USD 2025-12-19     16 0.06   0      0
##   Bid  Ask Vol   OI       LastTradeTime        IV   ITM Price ImpliedVol
## 1   0 0.01  NA 9781 2025-11-19 15:29:43 17.000005 FALSE 0.005         NA
## 2  NA   NA  NA   NA 2025-12-15 00:01:01  0.000000 FALSE    NA         NA
## 3   0 0.01   1 2970 2025-11-07 11:37:22  7.875000 FALSE 0.005         NA
## 4   0 0.01  NA 1423 2025-11-17 10:50:53  6.750002 FALSE 0.005         NA
## 5   0 0.01   1 7252 2025-12-15 10:16:40  6.500002 FALSE 0.005         NA
## 6   0 0.04   1 3089 2025-12-15 10:16:40  7.062501 FALSE 0.020         NA
```

3.4

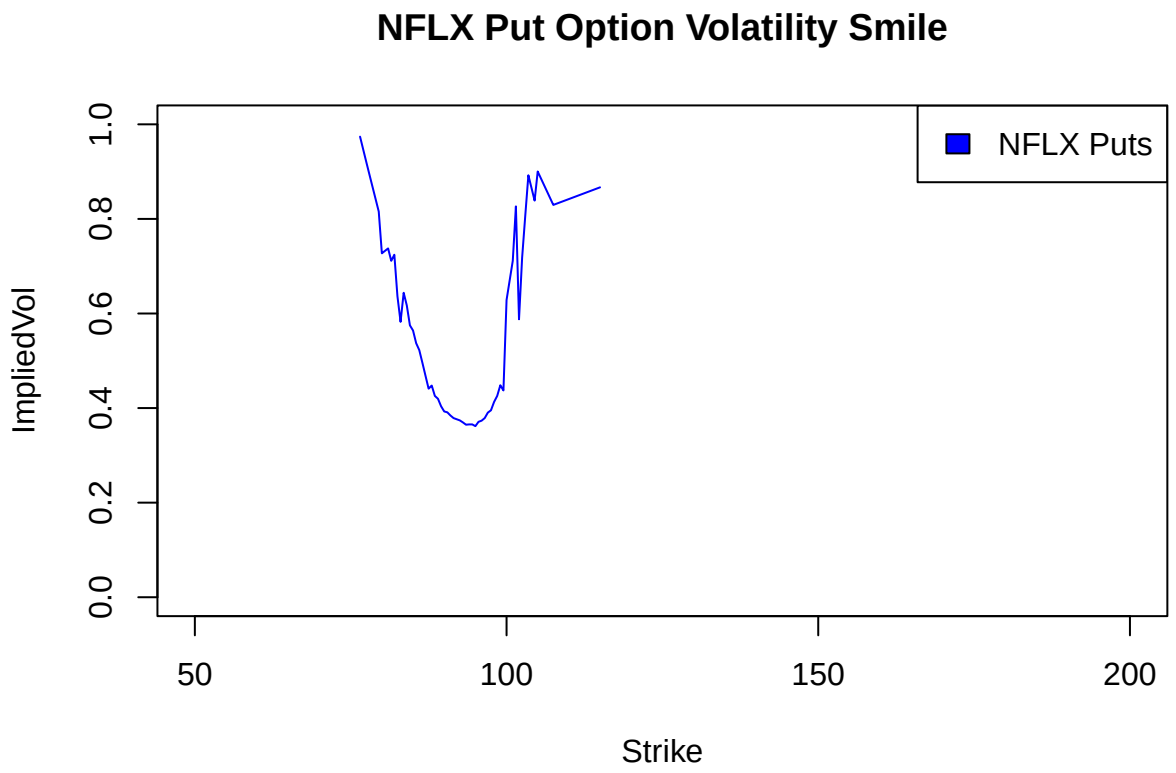
Choose 3 expiration date for put options, plot volatility smiles (Strike in x-axis and ImpliedVol in y-axis, similar to call smiles on page 22 of L9).

```
#defining index to exclude NA from plot
idx <- which(
  nflxOptns$puts$Strike > 0.5*S0 &
  nflxOptns$puts$Strike < 1.5*S0 &
  nflxOptns$puts$ImpliedVol < 1
)
```

```r
plot(NA,
     xlim = c(50,200),
     ylim = c(0,1),
     xlab = "Strike",
     ylab = "ImpliedVol",
     main = "NFLX Put Option Volatility Smile"
)

# Adding implied volatility curve
lines(
  nflxOptns$puts$Strike[idx],
  nflxOptns$puts$ImpliedVol[idx],
  col = "blue"
)

legend(
  "topright",
  legend = "NFLX Puts",
  fill = "blue"
)
```



3.5

Keep fields “Strike”,“Bid”,“Ask”, “Price”, and “ImpliedVol” and save the calls and puts of each expiration date in .csv file. Submit one of the .csv file also. (see page 19-20 in L5, format of file names is not restricted)

```r
# Save CALL options
write.csv(
  nflxOptns$calls[, c("Strike", "Bid", "Ask", "Price", "ImpliedVol")],
  "NFLX_calls.csv",
  row.names = FALSE
)

# Save PUT options
write.csv(
  nflxOptns$puts[, c("Strike", "Bid", "Ask", "Price", "ImpliedVol")],
  "NFLX_puts.csv",
  row.names = FALSE
)
```