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S(0) = 100, K = 100, T = 1, M = 100, r = 8%, vol = 20%

Use the following two sets of u and d for your program.

- Set 1: $u = e^{\sigma\sqrt{\Delta t}}; d = e^{-\sigma\sqrt{\Delta t}}$.
- Set 2: $u = e^{\sigma\sqrt{\Delta t}+(r-\frac{1}{2}\sigma^2)\Delta t}; u = e^{-\sigma\sqrt{\Delta t}+(r-\frac{1}{2}\sigma^2)\Delta t}$.

Here $\Delta t = \frac{T}{M}$, with M being the number of subintervals in the time interval $[0,T]$. Use the continuous compounding convention in your calculations (i.e., both in $\tilde{\mathbb{P}}$ and in the pricing formula).

QUESTION 1.

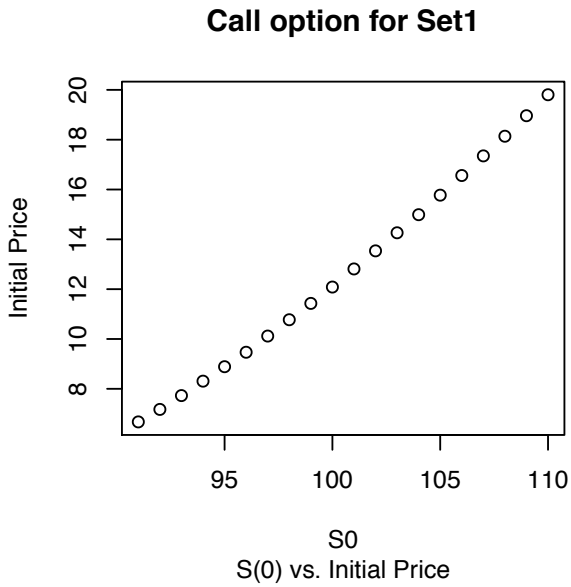
- European Options

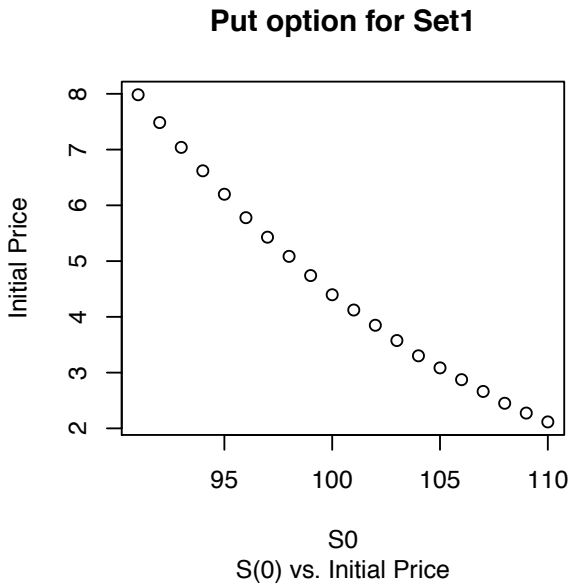
For the given two sets of u and d:

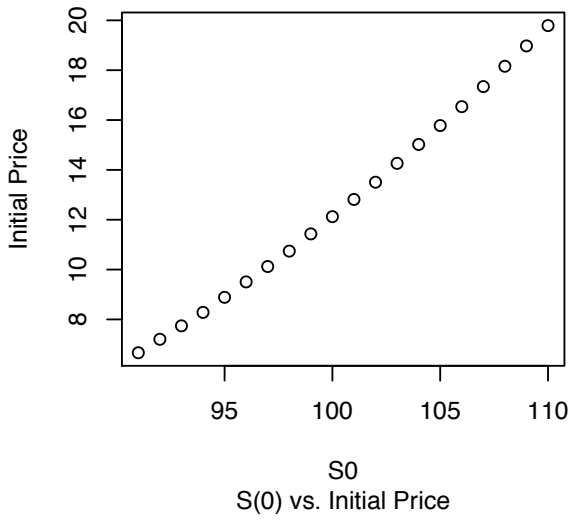
- Set 1.
  - Initial call option price = 12.08538 .
  - Initial put option price = 4.397015 .
- Set 2.
  - Initial call option price = 12.12305 .
  - Initial put option price = 4.434682 .

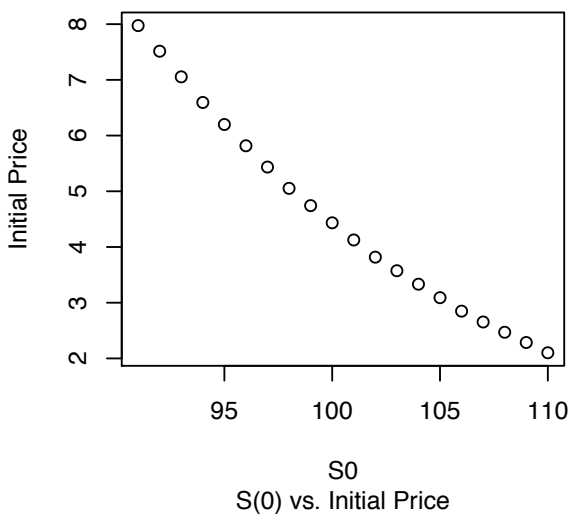
Now, plot of the initial prices of both call and put options (for both the given sets of u and d) by varying one of the parameters at a time (as given below) while keeping the other parameters fixed (as given above) :

A. S(0)

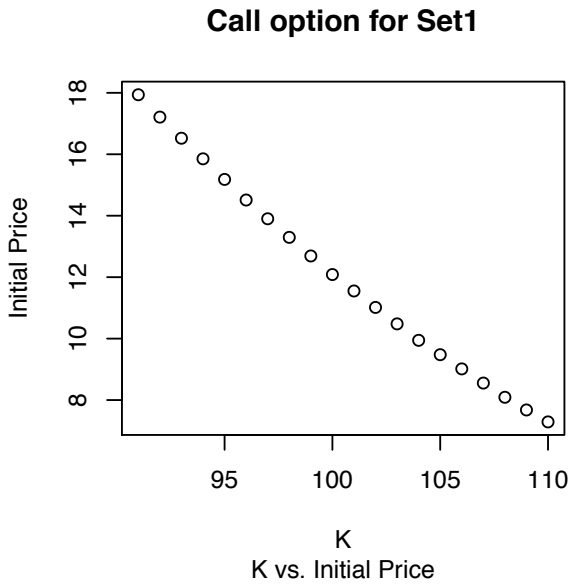

Call option for Set1
Initial Price
8
10
12
14
16
18
20
95
100
105
110
S0
S(0) vs. Initial Price

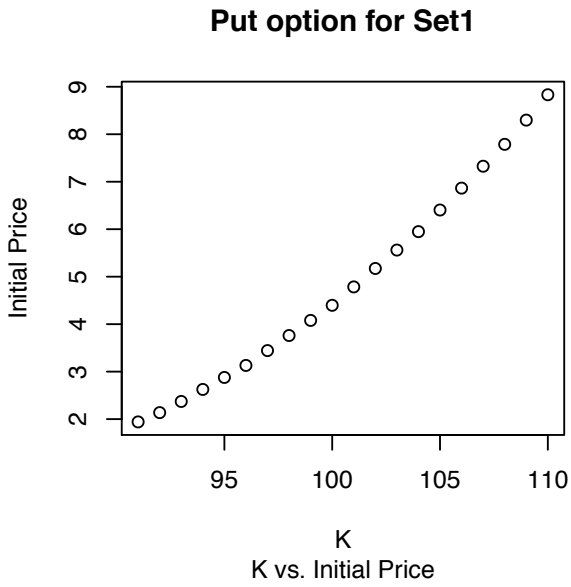

Put option for Set1
Initial Price
2
3
4
5
6
7
8
95
100
105
110
S0
S(0) vs. Initial Price

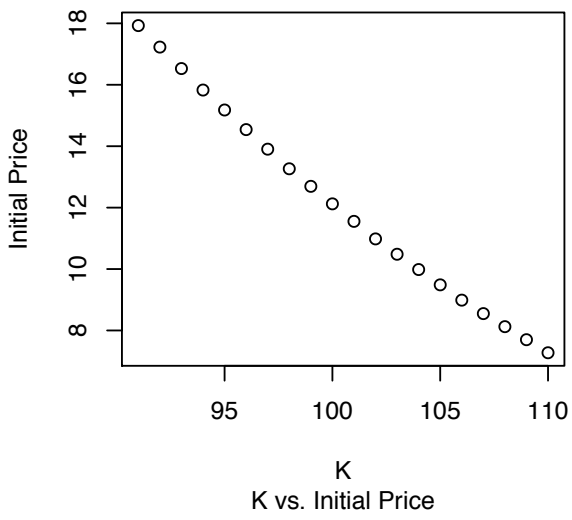

Call option for Set2
Initial Price
8
10
12
14
16
18
20
95
100
105
110
S0
S(0) vs. Initial Price

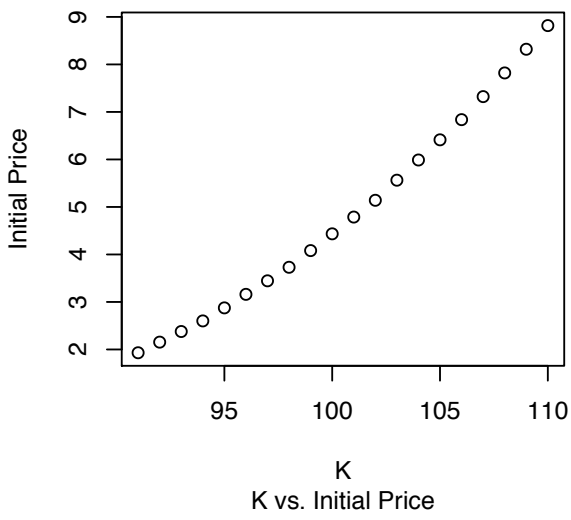

Put option for Set2
Initial Price
2
3
4
5
6
7
8
95
100
105
110
S0
S(0) vs. Initial Price

B. K

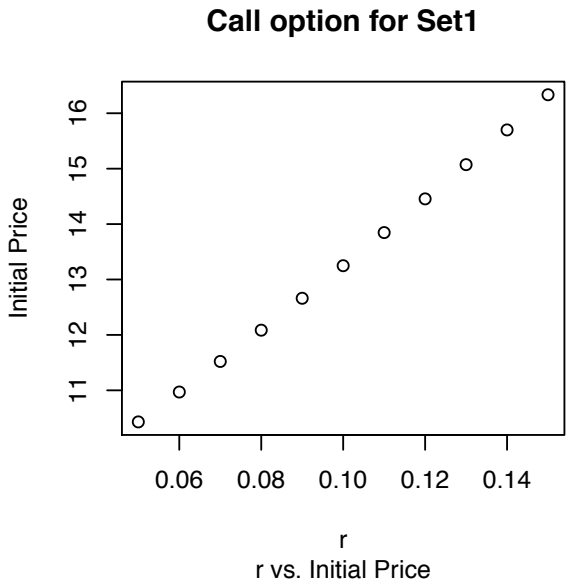

Call option for Set1
Initial Price
8
10
12
14
16
18
95
100
105
110
K
K vs. Initial Price

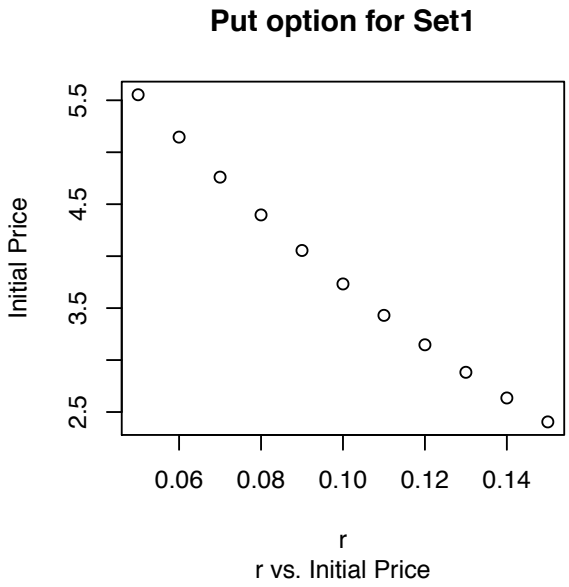

Put option for Set1
Initial Price
2
3
4
5
6
7
8
9
95
100
105
110
K
K vs. Initial Price

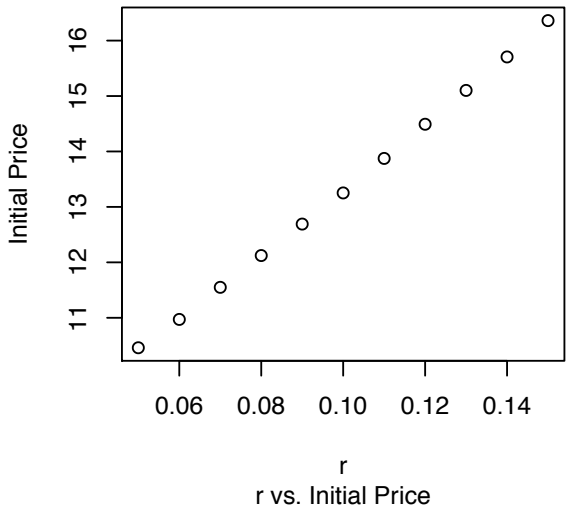

Call option for Set2
Initial Price
8
10
12
14
16
18
95
100
105
110
K
K vs. Initial Price

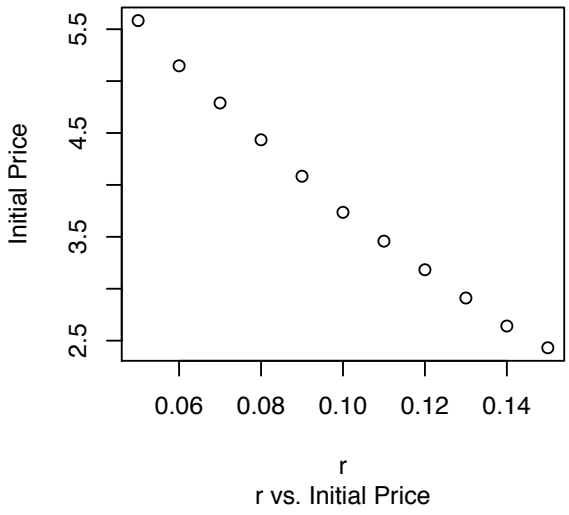

Put option for Set2
Initial Price
2
3
4
5
6
7
8
9
95
100
105
110
K
K vs. Initial Price

C. r

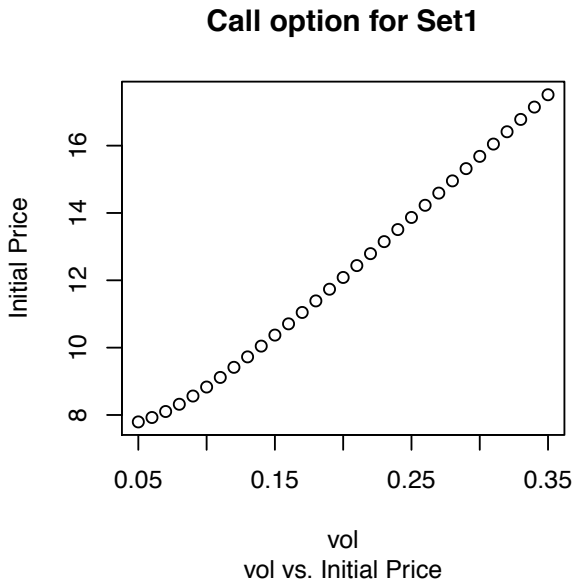

Call option for Set1
Initial Price
11
12
13
14
15
16
0.06
0.08
0.10
0.12
0.14
r
r vs. Initial Price

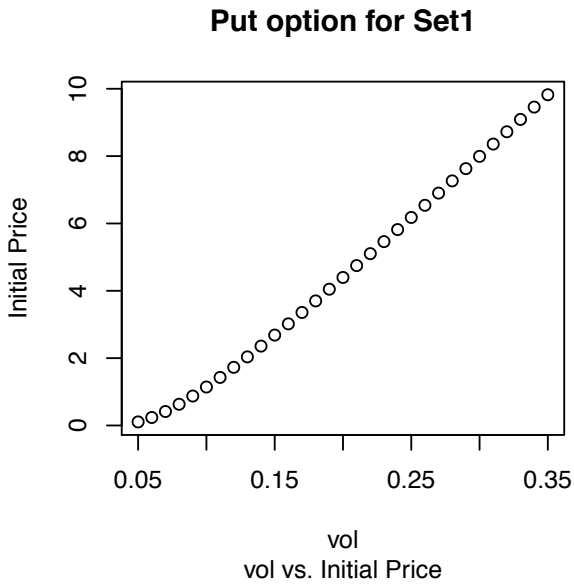

Put option for Set1
Initial Price
2.5
3.5
4.5
5.5
0.06
0.08
0.10
0.12
0.14
r
r vs. Initial Price

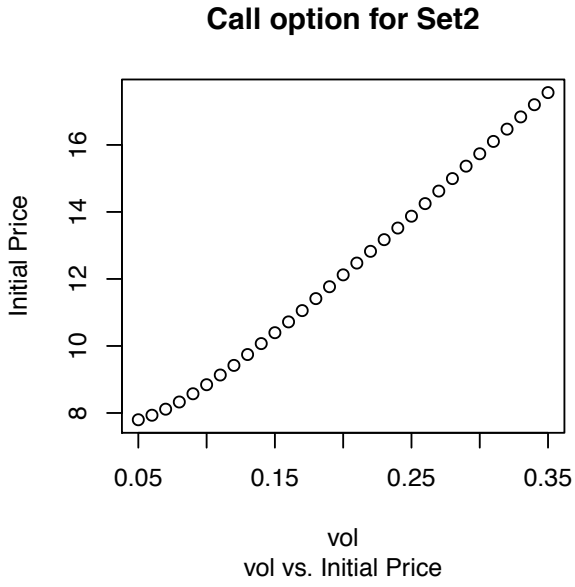

Call option for Set2
Initial Price
11
12
13
14
15
16
0.06
0.08
0.10
0.12
0.14
r
r vs. Initial Price


Put option for Set2
Initial Price
2.5
3.5
4.5
5.5
0.06
0.08
0.10
0.12
0.14
r
r vs. Initial Price

D. vol


Call option for Set1
Initial Price
8
10
12
14
16
0.05
0.15
0.25
0.35
vol
vol vs. Initial Price

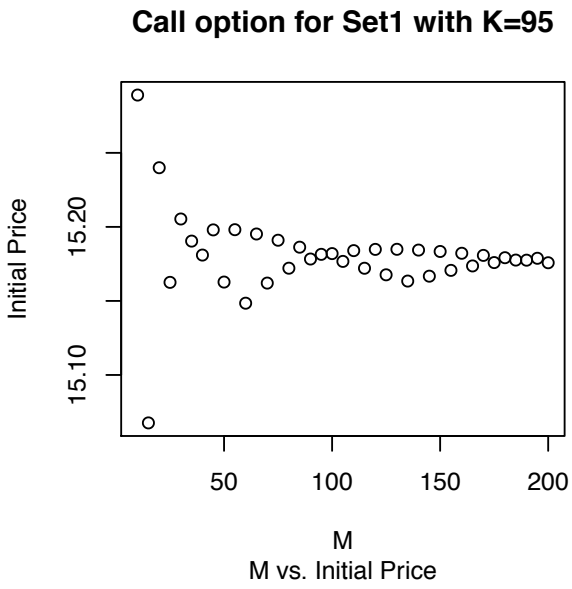

Put option for Set1
Initial Price
0
2
4
6
8
10
0.05
0.15
0.25
0.35
vol
vol vs. Initial Price

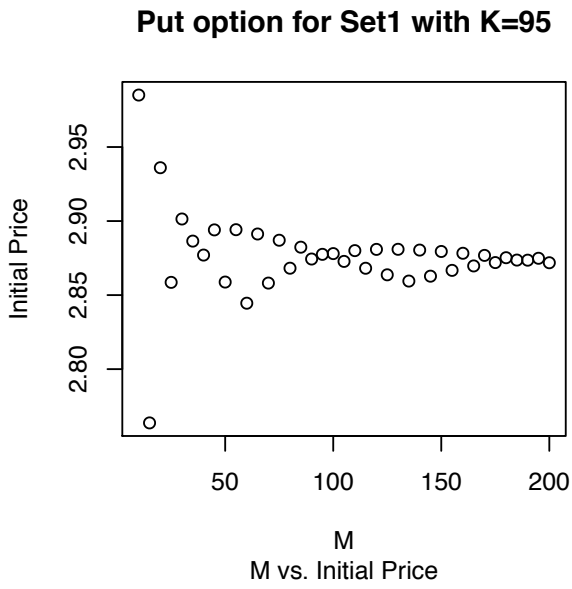

Call option for Set2
Initial Price
8
10
12
14
16
0.05
0.15
0.25
0.35
vol
vol vs. Initial Price

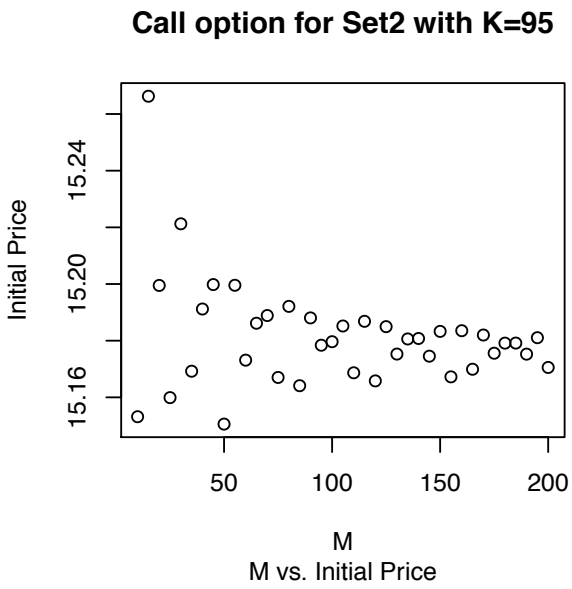

Put option for Set2
Initial Price
0
2
4
6
8
10
0.05
0.15
0.25
0.35
vol
vol vs. Initial Price

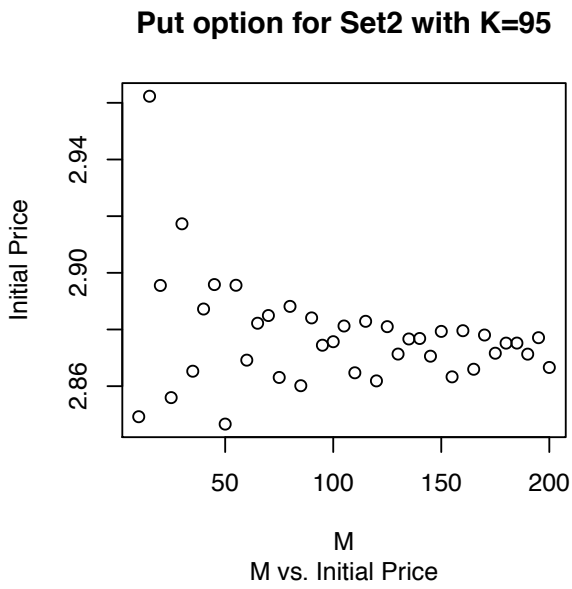
E. M (Do this for three values of K , K = 95; 100; 105).

- K = 95

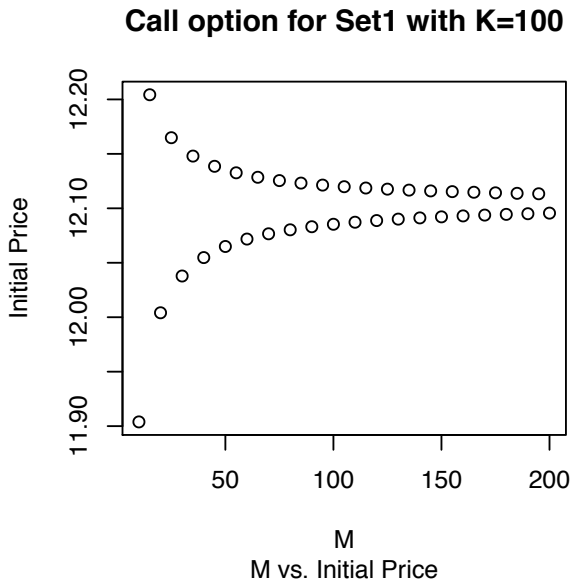


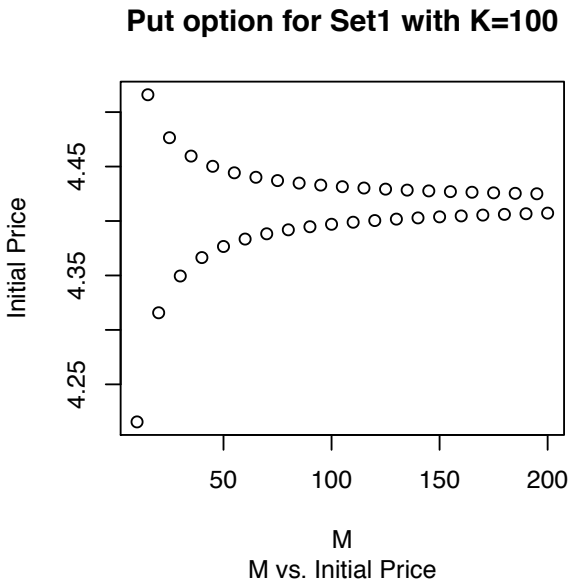


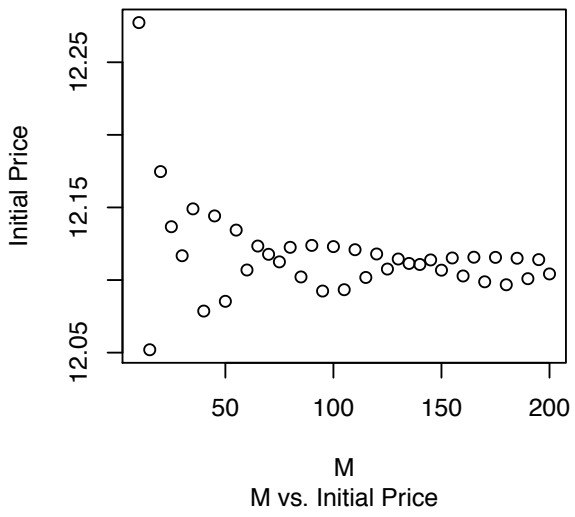


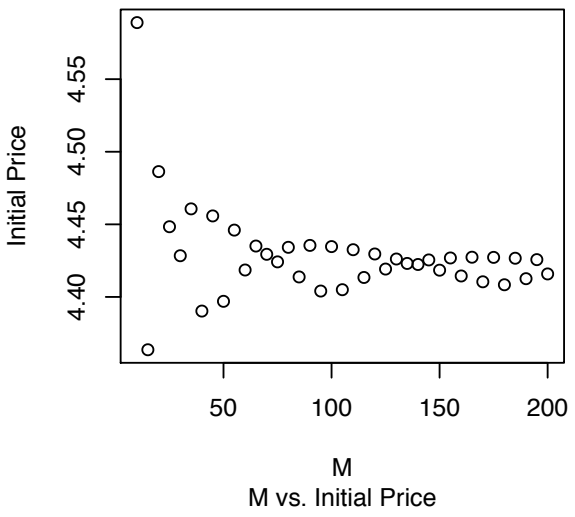


- K = 100

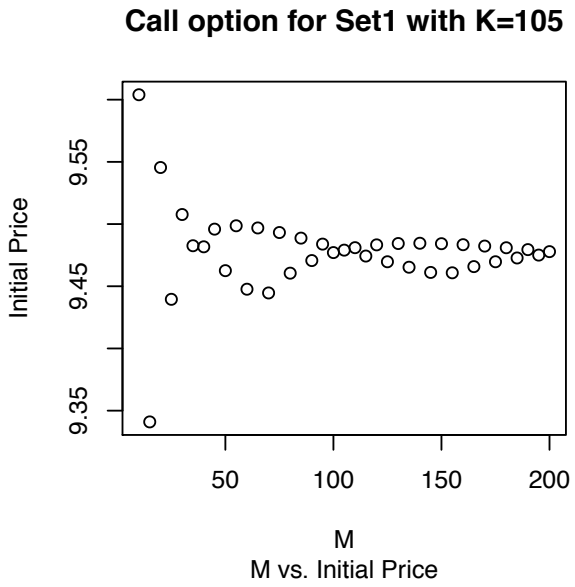

Call option for Set1 with K=100
Initial Price
11.90
12.00
12.10
12.20
50
100
150
200
M
M vs. Initial Price

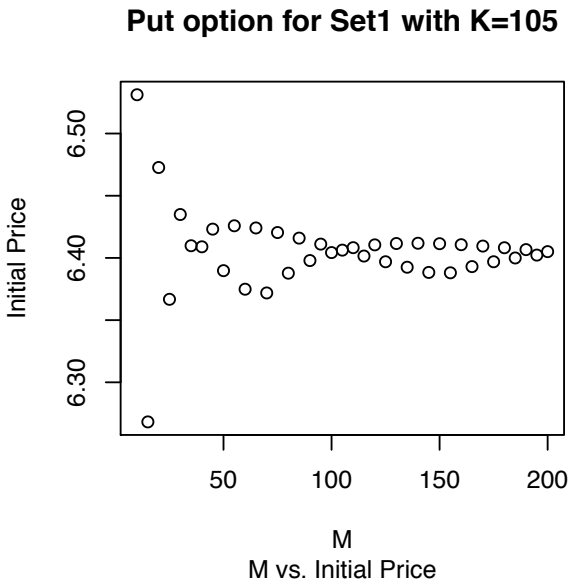

Put option for Set1 with K=100
Initial Price
4.25
4.35
4.45
50
100
150
200
M
M vs. Initial Price

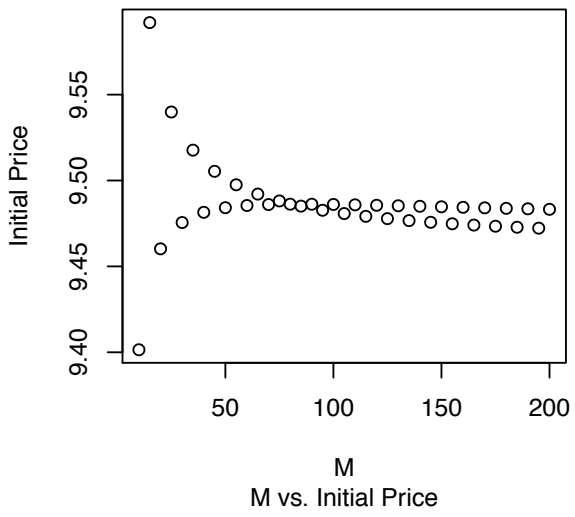

Call option for Set2 with K=100
Initial Price
12.05
12.15
12.25
50
100
150
200
M
M vs. Initial Price

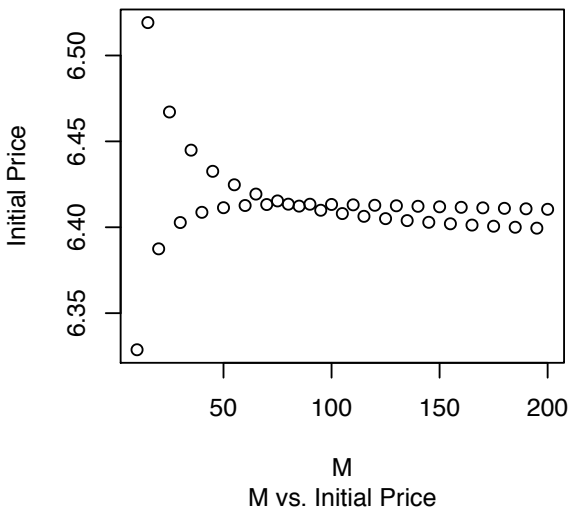

Put option for Set2 with K=100
Initial Price
4.40
4.45
4.50
4.55
50
100
150
200
M
M vs. Initial Price

- K = 105


Call option for Set1 with K=105
Initial Price
9.35
9.45
9.55
50
100
150
200
M
M vs. Initial Price


Put option for Set1 with K=105
Initial Price
6.30
6.40
6.50
50
100
150
200
M
M vs. Initial Price


Call option for Set2 with K=105
Initial Price
9.40
9.45
9.50
9.55
50
100
150
200
M
M vs. Initial Price


Put option for Set2 with K=105
Initial Price
6.35
6.40
6.45
6.50
50
100
150
200
M
M vs. Initial Price

QUESTION 2.

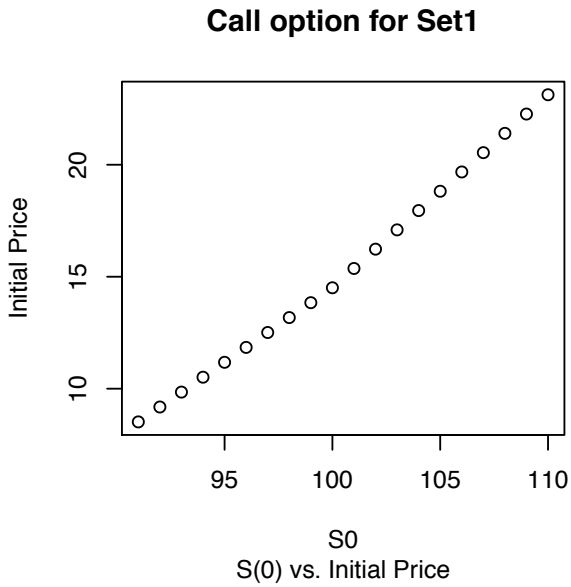
- Look-back Options

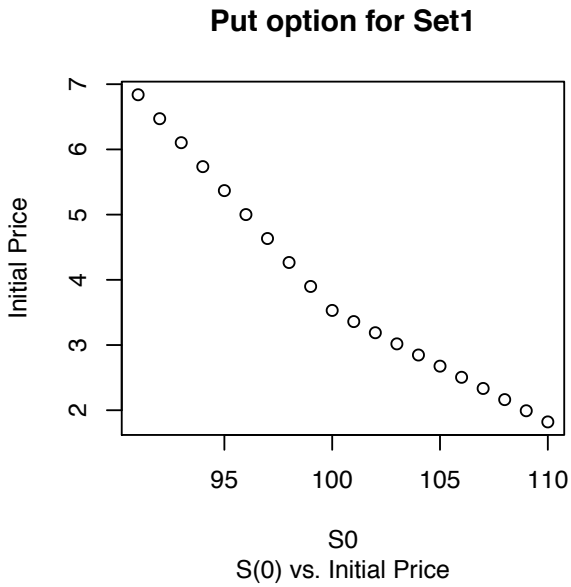
For the given two sets of u and d:

- Set 1.
  - Initial call option price = 14.50656 .
  - Initial put option price = 3.530844 .
- Set 2.
  - Initial call option price = 14.9511 .
  - Initial put option price = 3.905206 .

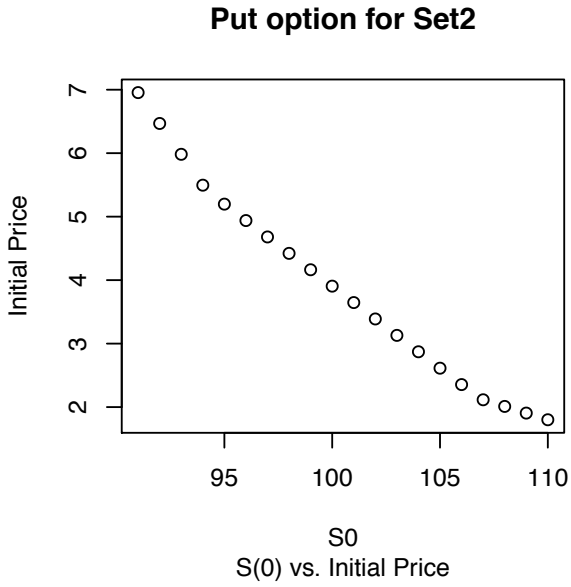
Now, plot of the initial prices of both call and put options (for both the given sets of u and d) by varying one of the parameters at a time (as given below) while keeping the other parameters fixed (as given above) :

A. S(0)

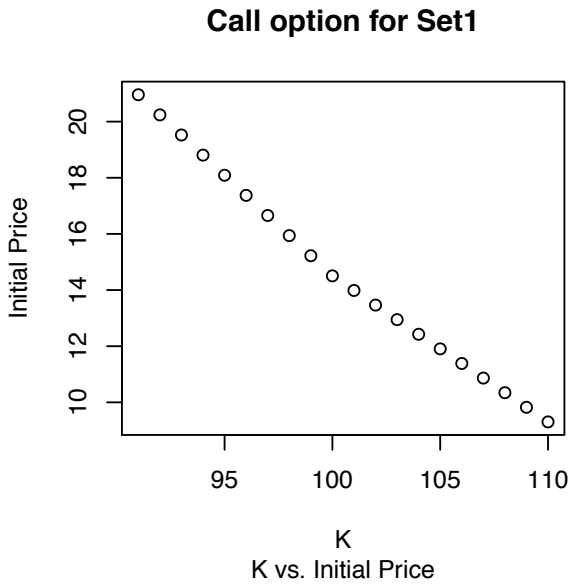

Call option for Set1
Initial Price
10
15
20
95
100
105
110
S0
S(0) vs. Initial Price

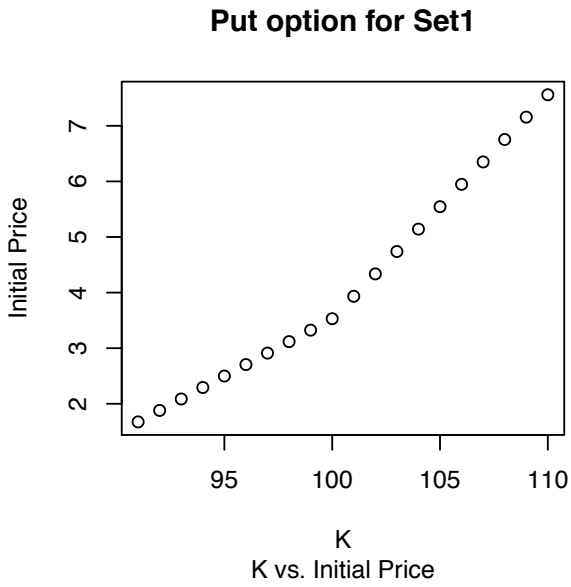

Put option for Set1
Initial Price
2
3
4
5
6
7
95
100
105
110
S0
S(0) vs. Initial Price

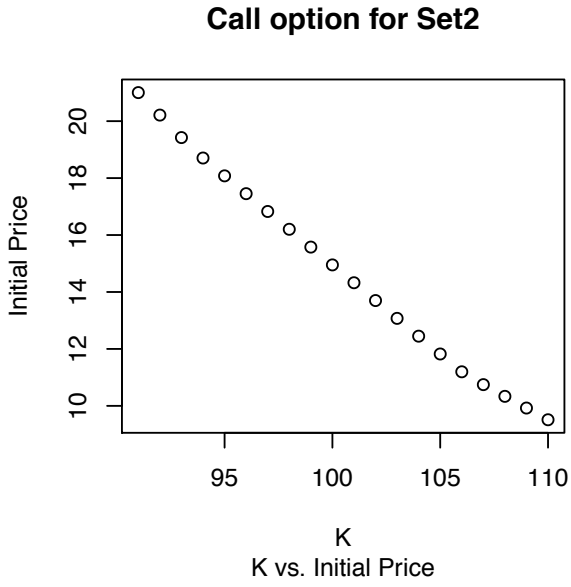

Call option for Set2
Initial Price
10
15
20
95
100
105
110
S0
S(0) vs. Initial Price


Put option for Set2
Initial Price
2
3
4
5
6
7
95
100
105
110
S0
S(0) vs. Initial Price

B. K

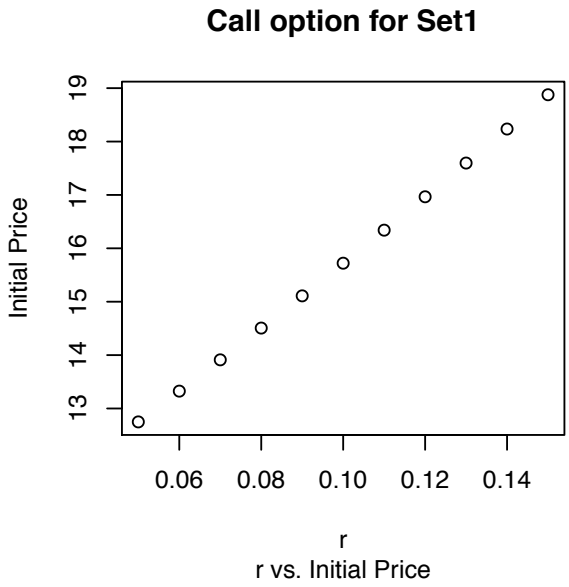

Call option for Set1
Initial Price
10
12
14
16
18
20
95
100
105
110
K
K vs. Initial Price

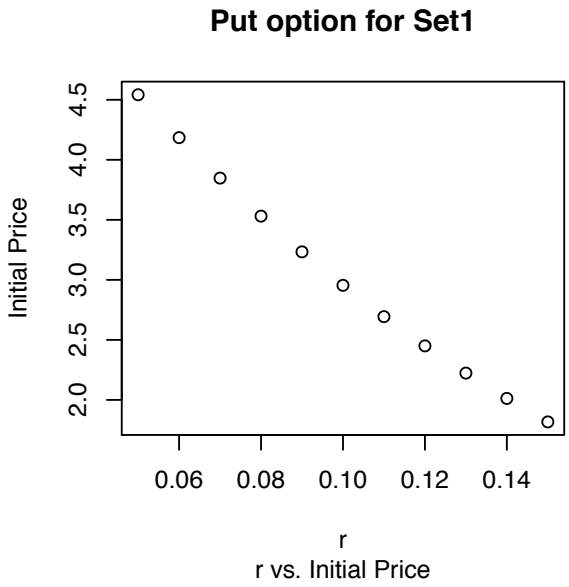

Put option for Set1
Initial Price
2
3
4
5
6
7
95
100
105
110
K
K vs. Initial Price

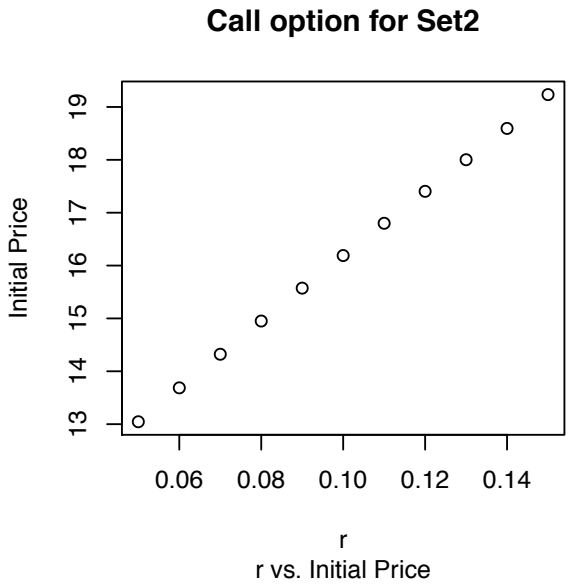

Call option for Set2
Initial Price
10
12
14
16
18
20
95
100
105
110
K
K vs. Initial Price

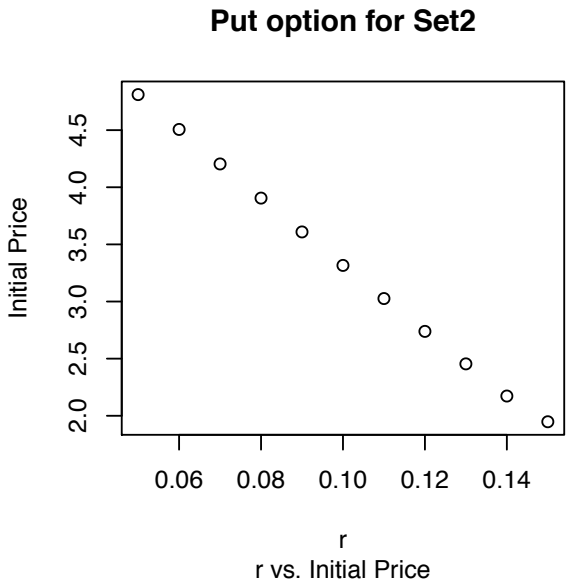

Put option for Set2
Initial Price
2
3
4
5
6
7
95
100
105
110
K
K vs. Initial Price

C. r

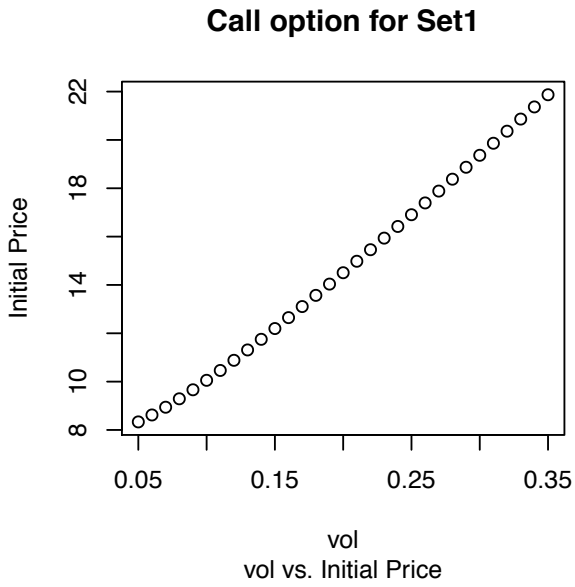

Call option for Set1
Initial Price
13 14 15 16 17 18 19
0.06 0.08 0.10 0.12 0.14
r
r vs. Initial Price

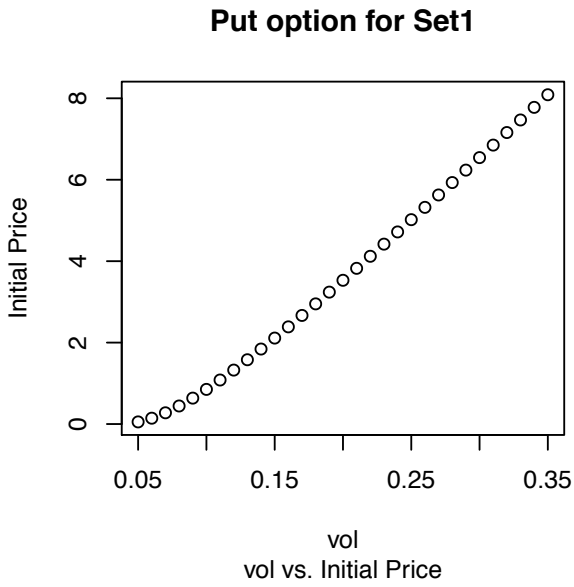

Put option for Set1
Initial Price
2.0 2.5 3.0 3.5 4.0 4.5
0.06 0.08 0.10 0.12 0.14
r
r vs. Initial Price

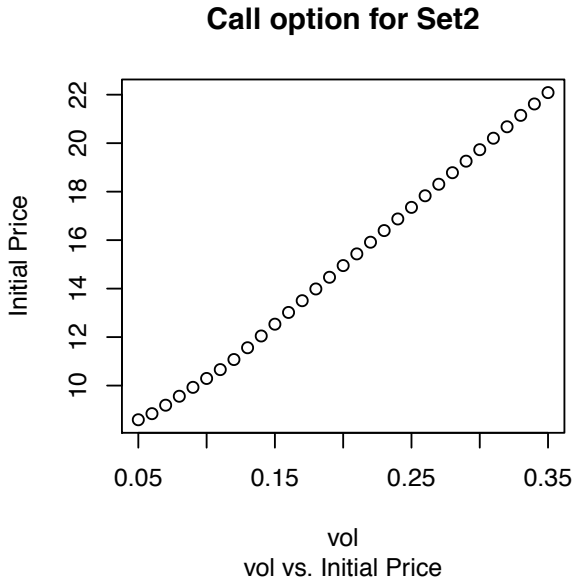

Call option for Set2
Initial Price
13 14 15 16 17 18 19
0.06 0.08 0.10 0.12 0.14
r
r vs. Initial Price


Put option for Set2
Initial Price
2.0 2.5 3.0 3.5 4.0 4.5
0.06 0.08 0.10 0.12 0.14
r
r vs. Initial Price

D. vol


Call option for Set1
Initial Price
8
10
14
18
22
0.05
0.15
0.25
0.35
vol
vol vs. Initial Price

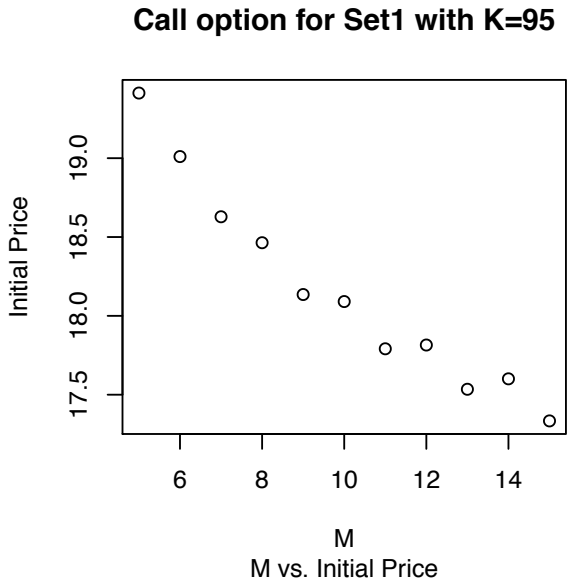

Put option for Set1
Initial Price
0
2
4
6
8
0.05
0.15
0.25
0.35
vol
vol vs. Initial Price

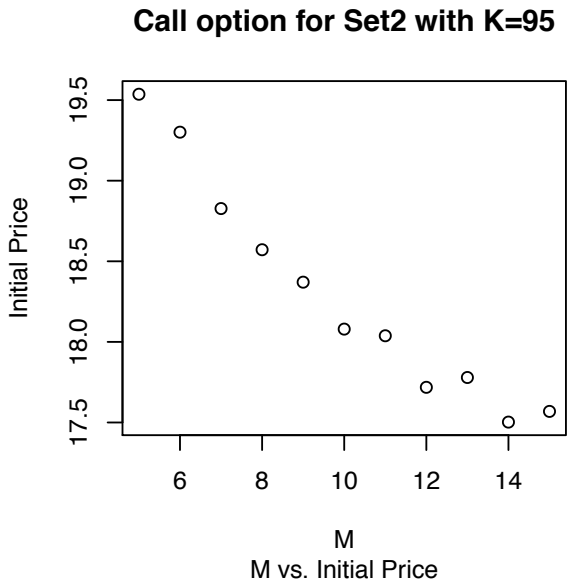

Call option for Set2
Initial Price
10
12
14
16
18
20
22
0.05
0.15
0.25
0.35
vol
vol vs. Initial Price

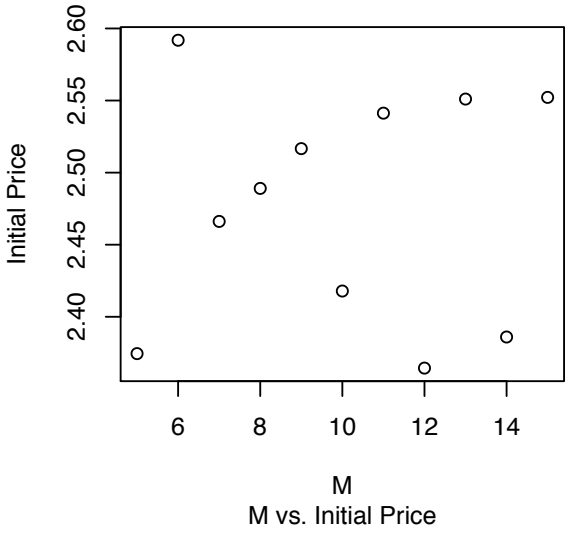

Put option for Set2
Initial Price
0
2
4
6
8
0.05
0.15
0.25
0.35
vol
vol vs. Initial Price

E. M (Do this for three values of K , K = 95; 100; 105).

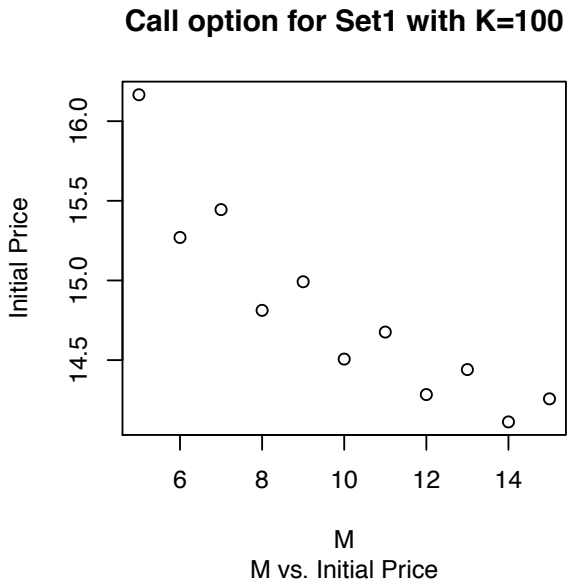
- K = 95

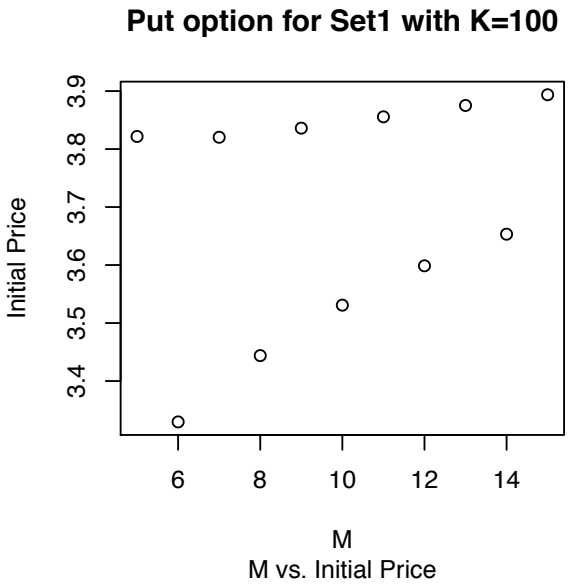


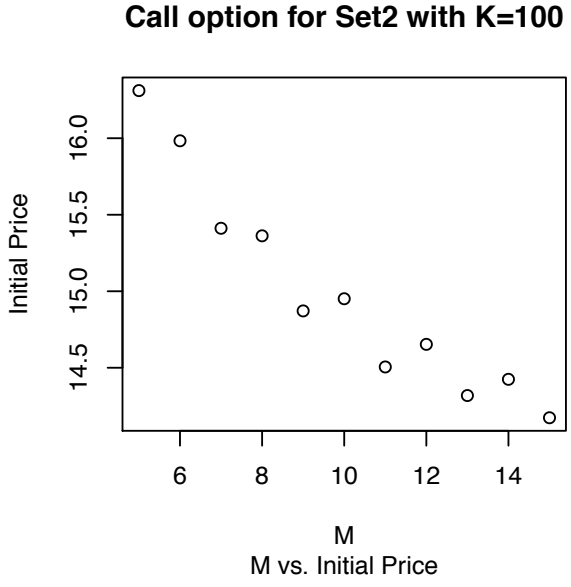


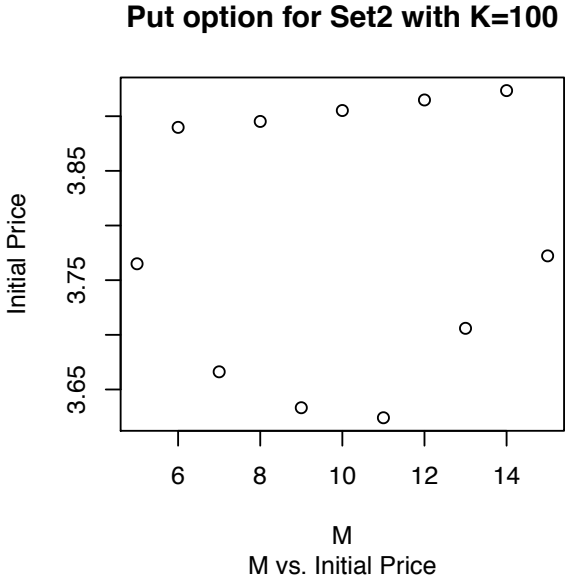


- K = 100

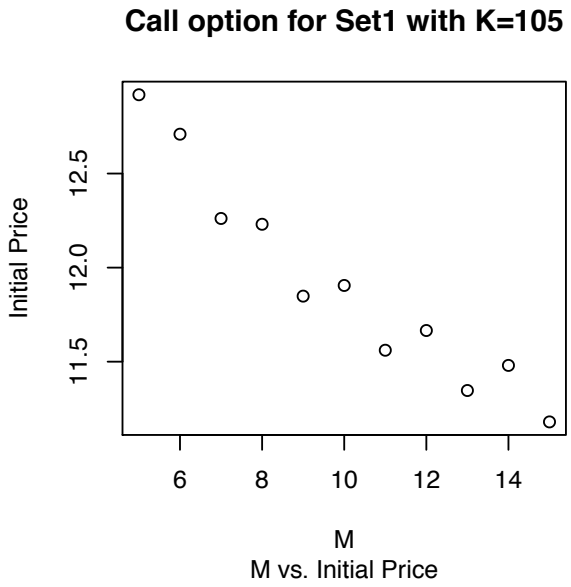

Call option for Set1 with K=100
Initial Price
14.5
15.0
15.5
16.0
6
8
10
12
14
M
M vs. Initial Price

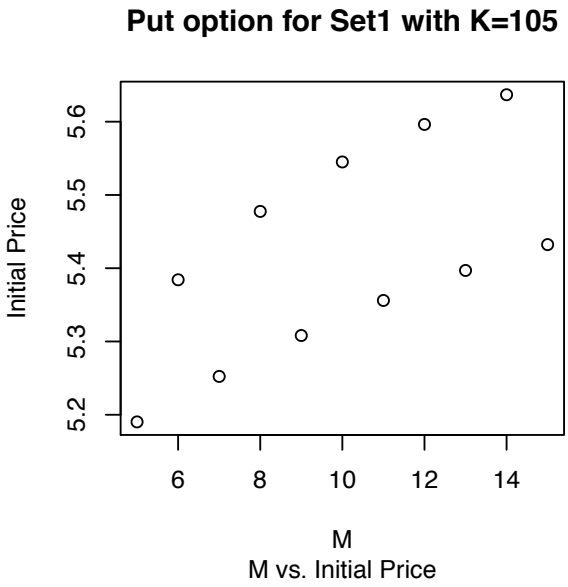

Put option for Set1 with K=100
Initial Price
3.4
3.5
3.6
3.7
3.8
3.9
6
8
10
12
14
M
M vs. Initial Price

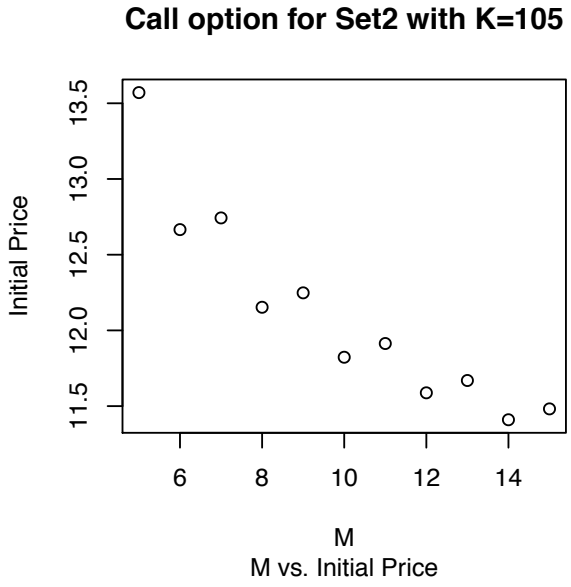

Call option for Set2 with K=100
Initial Price
14.5
15.0
15.5
16.0
6
8
10
12
14
M
M vs. Initial Price

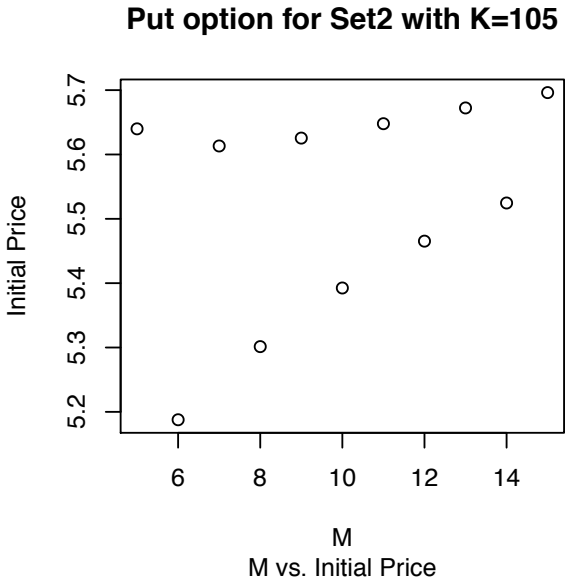

Put option for Set2 with K=100
Initial Price
3.65
3.75
3.85
6
8
10
12
14
M
M vs. Initial Price

- K = 105


Call option for Set1 with K=105
Initial Price
11.5
12.0
12.5
6
8
10
12
14
M
M vs. Initial Price


Put option for Set1 with K=105
Initial Price
5.2
5.3
5.4
5.5
5.6
6
8
10
12
14
M
M vs. Initial Price


Call option for Set2 with K=105
Initial Price
11.5
12.0
12.5
13.0
13.5
6
8
10
12
14
M
M vs. Initial Price


Put option for Set2 with K=105
Initial Price
5.2
5.3
5.4
5.5
5.6
5.7
6
8
10
12
14
M
M vs. Initial Price

CODE (R)

SCRIPT FOR QUESTION 1.

```
#European Options

rm(list = ls());

pos <- function(x){
  ind = which(x < 0)
  z = x
  z[ind] <- 0  ## z now contains the x^+
  return(z)
}

binopt <- function( S0, K, r, t, M, vol, Flag, uFlag ){
  dt = t/M;

  time <- seq(0, t, by=dt);

  if (uFlag == 'a'){
    u = exp(vol*sqrt(dt));
    d = exp(-vol*sqrt(dt));
  } else if (uFlag == 'b'){
    u = exp(vol*sqrt(dt) + (r-((vol^2)/2))*dt);
    d = exp(-vol*sqrt(dt) + (r-((vol^2)/2))*dt);
  }

  #Continuous Compounding so "exp(r*dt)".
  if ((d > exp(r*dt)) | (exp(r*dt) > u)){
    stop('ArbitargePossible as "d < exp(r*dt) < u" not true.');
  }

  AssetPrice <- matrix(0, nrow = (M+1), ncol = (M+1));
  OptionValue <- matrix(0, nrow = (M+1), ncol = (M+1));

  AssetPrice[1,1] = S0;
  for (i in 2:(M+1)){
    AssetPrice[1, i] <- AssetPrice[1, (i-1)]*u;
    AssetPrice[2:i, i] <- AssetPrice[1:(i-1), (i-1)]*d;
  }

  #Flag = 1 for a call option, or Flag = 0 for a put option.
  if (Flag == 1){

    OptionValue[, M+1] <- pos(AssetPrice[, M+1] - K);
  }
  else if (Flag == 0){
    OptionValue[, M+1] <- pos(K - AssetPrice[, M+1]);
  }

  #Continuous Compounding so "exp(r*dt)".
  p_ = (exp(r*dt) - d)/(u-d);
  q_ = (u - exp(r*dt))/(u-d);

  for (i in seq(M, 1, by=-1)){
    OptionValue[1:i, i] <- (p_*OptionValue[1:i, i+1] + q_*OptionValue[2:(i+1), i+1])/
exp(r*dt);
  }

  result <- list("AssetPrice" = AssetPrice, "OptionValue" = OptionValue, "time" =
time);
```

```
  return(result);
}

S0 = 100;
K = 100;
t = 1;
M = 100;
r = 0.08;
vol = 0.2;

cat("Set 1.\n");
cat("Initial call option price =", (binopt( S0, K, r, t, M, vol, 1 , 'a' )$OptionValue)
[1,1], ".\n");
cat("Initial put option price =", (binopt( S0, K, r, t, M, vol, 0 , 'a' )$OptionValue)
[1,1], ".\n");

cat("Set 2.\n");
cat("Initial call option price =", (binopt( S0, K, r, t, M, vol, 1 , 'b' )$OptionValue)
[1,1], ".\n");
cat("Initial put option price =", (binopt( S0, K, r, t, M, vol, 0 , 'b' )$OptionValue)
[1,1], ".\n");

##Part a.
S0 = 91:110;
a1c <- 1:length(S0); a1p <- 1:length(S0);
a2c <- 1:length(S0); a2p <- 1:length(S0);

for (i in 1:length(S0)) {
  a1c[i] <- (binopt( S0[i], K, r, t, M, vol, 1 , 'a' )$OptionValue)[1,1];
  a1p[i] <- (binopt( S0[i], K, r, t, M, vol, 0 , 'a' )$OptionValue)[1,1];
  a2c[i] <- (binopt( S0[i], K, r, t, M, vol, 1 , 'b' )$OptionValue)[1,1];
  a2p[i] <- (binopt( S0[i], K, r, t, M, vol, 0 , 'b' )$OptionValue)[1,1];
}
pdf("1a.pdf");
par(mfrow=c(2,2));
plot(S0,a1c, main="Call option for Set1", sub="S(0) vs. Initial Price",
     xlab="S0", ylab="Initial Price");
plot(S0,a1p, main="Put option for Set1", sub="S(0) vs. Initial Price",
     xlab="S0", ylab="Initial Price");
plot(S0,a2c, main="Call option for Set2", sub="S(0) vs. Initial Price",
     xlab="S0", ylab="Initial Price");
plot(S0,a2p, main="Put option for Set2", sub="S(0) vs. Initial Price",
     xlab="S0", ylab="Initial Price");

dev.off();

S0 = 100;
#*#

##Part b.
K = 91:110;
b1c <- 1:length(K); b1p <- 1:length(K);
b2c <- 1:length(K); b2p <- 1:length(K);

for (i in 1:length(K)) {
  b1c[i] <- (binopt( S0, K[i], r, t, M, vol, 1 , 'a' )$OptionValue)[1,1];
  b1p[i] <- (binopt( S0, K[i], r, t, M, vol, 0 , 'a' )$OptionValue)[1,1];
  b2c[i] <- (binopt( S0, K[i], r, t, M, vol, 1 , 'b' )$OptionValue)[1,1];
  b2p[i] <- (binopt( S0, K[i], r, t, M, vol, 0 , 'b' )$OptionValue)[1,1];
}

pdf("1b.pdf");
par(mfrow=c(2,2));
```

```
plot(K,b1c, main="Call option for Set1", sub="K vs. Initial Price",
     xlab="K", ylab="Initial Price");
plot(K,b1p, main="Put option for Set1", sub="K vs. Initial Price",
     xlab="K", ylab="Initial Price");
plot(K,b2c, main="Call option for Set2", sub="K vs. Initial Price",
     xlab="K", ylab="Initial Price");
plot(K,b2p, main="Put option for Set2", sub="K vs. Initial Price",
     xlab="K", ylab="Initial Price");

dev.off();

K = 100;
#*#

##Part c.
r = seq(0.05, 0.15, by=0.01);
c1c <- 1:length(r); c1p <- 1:length(r);
c2c <- 1:length(r); c2p <- 1:length(r);

for (i in 1:length(r)) {
  c1c[i] <- (binopt( S0, K, r[i], t, M, vol, 1 , 'a' )$OptionValue)[1,1];
  c1p[i] <- (binopt( S0, K, r[i], t, M, vol, 0 , 'a' )$OptionValue)[1,1];
  c2c[i] <- (binopt( S0, K, r[i], t, M, vol, 1 , 'b' )$OptionValue)[1,1];
  c2p[i] <- (binopt( S0, K, r[i], t, M, vol, 0 , 'b' )$OptionValue)[1,1];
}

pdf("1c.pdf");
par(mfrow=c(2,2));
plot(r,c1c, main="Call option for Set1", sub="r vs. Initial Price",
     xlab="r", ylab="Initial Price");
plot(r,c1p, main="Put option for Set1", sub="r vs. Initial Price",
     xlab="r", ylab="Initial Price");
plot(r,c2c, main="Call option for Set2", sub="r vs. Initial Price",
     xlab="r", ylab="Initial Price");
plot(r,c2p, main="Put option for Set2", sub="r vs. Initial Price",
     xlab="r", ylab="Initial Price");

dev.off();

r = 0.08;
#*#

##Part d.
vol = seq(0.05, 0.35, by=0.01);
d1c <- 1:length(vol); d1p <- 1:length(vol);
d2c <- 1:length(vol); d2p <- 1:length(vol);

for (i in 1:length(vol)) {
  d1c[i] <- (binopt( S0, K, r, t, M, vol[i], 1 , 'a' )$OptionValue)[1,1];
  d1p[i] <- (binopt( S0, K, r, t, M, vol[i], 0 , 'a' )$OptionValue)[1,1];
  d2c[i] <- (binopt( S0, K, r, t, M, vol[i], 1 , 'b' )$OptionValue)[1,1];
  d2p[i] <- (binopt( S0, K, r, t, M, vol[i], 0 , 'b' )$OptionValue)[1,1];
}

pdf("1d.pdf");
par(mfrow=c(2,2));
plot(vol,d1c, main="Call option for Set1", sub="vol vs. Initial Price",
     xlab="vol", ylab="Initial Price");
plot(vol,d1p, main="Put option for Set1", sub="vol vs. Initial Price",
     xlab="vol", ylab="Initial Price");
plot(vol,d2c, main="Call option for Set2", sub="vol vs. Initial Price",
     xlab="vol", ylab="Initial Price");
plot(vol,d2p, main="Put option for Set2", sub="vol vs. Initial Price",
```

```
     xlab="vol", ylab="Initial Price");

dev.off();

vol = 0.2;
#*#

##Part e.
M = seq(10, 200, by=5);
e1c_k95 <- 1:length(M); e1c_k100 <- 1:length(M); e1c_k105 <- 1:length(M);
e1p_k95 <- 1:length(M); e1p_k100 <- 1:length(M); e1p_k105 <- 1:length(M);
e2c_k95 <- 1:length(M); e2c_k100 <- 1:length(M); e2c_k105 <- 1:length(M);
e2p_k95 <- 1:length(M); e2p_k100 <- 1:length(M); e2p_k105 <- 1:length(M);

for (i in 1:length(M)) {
  e1c_k95[i] <- (binopt( S0, 95, r, t, M[i], vol, 1 , 'a' )$OptionValue)[1,1];
  e1p_k95[i] <- (binopt( S0, 95, r, t, M[i], vol, 0 , 'a' )$OptionValue)[1,1];
  e2c_k95[i] <- (binopt( S0, 95, r, t, M[i], vol, 1 , 'b' )$OptionValue)[1,1];
  e2p_k95[i] <- (binopt( S0, 95, r, t, M[i], vol, 0 , 'b' )$OptionValue)[1,1];

  e1c_k100[i] <- (binopt( S0, 100, r, t, M[i], vol, 1 , 'a' )$OptionValue)[1,1];
  e1p_k100[i] <- (binopt( S0, 100, r, t, M[i], vol, 0 , 'a' )$OptionValue)[1,1];
  e2c_k100[i] <- (binopt( S0, 100, r, t, M[i], vol, 1 , 'b' )$OptionValue)[1,1];
  e2p_k100[i] <- (binopt( S0, 100, r, t, M[i], vol, 0 , 'b' )$OptionValue)[1,1];

  e1c_k105[i] <- (binopt( S0, 105, r, t, M[i], vol, 1 , 'a' )$OptionValue)[1,1];
  e1p_k105[i] <- (binopt( S0, 105, r, t, M[i], vol, 0 , 'a' )$OptionValue)[1,1];
  e2c_k105[i] <- (binopt( S0, 105, r, t, M[i], vol, 1 , 'b' )$OptionValue)[1,1];
  e2p_k105[i] <- (binopt( S0, 105, r, t, M[i], vol, 0 , 'b' )$OptionValue)[1,1];
}

pdf("1e_k95.pdf");
par(mfrow=c(2,2));
plot(M,e1c_k95, main="Call option for Set1 with K=95", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");
plot(M,e1p_k95, main="Put option for Set1 with K=95", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");
plot(M,e2c_k95, main="Call option for Set2 with K=95", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");
plot(M,e2p_k95, main="Put option for Set2 with K=95", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");

dev.off();

pdf("1e_k100.pdf");
par(mfrow=c(2,2));
plot(M,e1c_k100, main="Call option for Set1 with K=100", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");
plot(M,e1p_k100, main="Put option for Set1 with K=100", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");
plot(M,e2c_k100, main="Call option for Set2 with K=100", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");
plot(M,e2p_k100, main="Put option for Set2 with K=100", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");

dev.off();

pdf("1e_k105.pdf");
par(mfrow=c(2,2));
plot(M,e1c_k105, main="Call option for Set1 with K=105", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");
plot(M,e1p_k105, main="Put option for Set1 with K=105", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");
```

```
plot(M,e2c_k105, main="Call option for Set2 with K=105", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");
plot(M,e2p_k105, main="Put option for Set2 with K=105", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");

dev.off();

M = 100;
#*#

rm(list = ls())
```

SCRIPT FOR QUESTION 2.

```
#Lookback Options

rm(list = ls());

pos <- function(x){
  ind = which(x < 0)
  z = x
  z[ind] <- 0  ## z now contains the x^+
  return(z)
}

greater <- function(x, y){
  ind = which(x < y)
  z = x
  z[ind] <- y[ind]  ## z now contains the max(x,y) iterative.
  return(z)
}

binopt <- function( S0, K, r, t, M, vol, Flag, uFlag ){
  dt = t/M;

  time <- seq(0, t, by=dt);

  if (uFlag == 'a'){
    u = exp(vol*sqrt(dt));
    d = exp(-vol*sqrt(dt));
  } else if (uFlag == 'b'){
    u = exp(vol*sqrt(dt) + (r-((vol^2)/2))*dt);
    d = exp(-vol*sqrt(dt) + (r-((vol^2)/2))*dt);
  }

  #Continuous Compounding so "exp(r*dt)".
  if ((d > exp(r*dt)) | (exp(r*dt) > u)){
    stop('ArbitargePossible as "d < exp(r*dt) < u" not true.');
  }

  AssetPrice <- matrix(0, nrow = (2^M), ncol = (M+1));
  OptionValue <- matrix(0, nrow = (2^M), ncol = (M+1));

  MaxAsset <- matrix(0, nrow = (2^M), ncol = (M+1));

  AssetPrice[1,1] = S0; MaxAsset[1,1] = S0;

  for (i in 2:(M+1)){
    AssetPrice[seq(1, 2^(i-1), 2), i] <- AssetPrice[(1:2^(i-2)), (i-1)]*u;
    AssetPrice[seq(2, 2^(i-1), 2), i] <- AssetPrice[(1:2^(i-2)), (i-1)]*d;

    MaxAsset[seq(1, 2^(i-1), 2), i] <- greater(AssetPrice[seq(1, 2^(i-1), 2), i], Max-
Asset[(1:2^(i-2)), i]);
    MaxAsset[seq(2, 2^(i-1), 2), i] <- greater(AssetPrice[seq(2, 2^(i-1), 2), i], Max-
Asset[(1:2^(i-2)), i])
  }

  #Flag = 1 for a call option, or Flag = 0 for a put option.
  if (Flag == 1){
    OptionValue[, M+1] <- pos(MaxAsset[, M+1] - K);
  }
  else if (Flag == 0){
    OptionValue[, M+1] <- pos(K - MaxAsset[, M+1]);
  }
```

```
  #Continuous Compounding so "exp(r*dt)".
  p_ = (exp(r*dt) - d)/(u-d);
  q_ = (u - exp(r*dt))/(u-d);

  for (i in seq(M, 1, by=-1)){
    #for European Options:
    #OptionValue[1:i, i] <- (p_*OptionValue[1:i, i+1] + q_*OptionValue[2:(i+1), i+1])/
exp(r*dt);
    #for American Options:
    #if (Flag == 1){
    #  OptionValue[1:i, i] <- greater(pos(AssetPrice[1:i, i] - K), (p_*OptionValue[1:i,
i+1] + q_*OptionValue[2:(i+1), i+1])/exp(r*dt));
    #}
    #else if (Flag == 0){
    #  OptionValue[1:i, i] <- greater(pos(K - AssetPrice[1:i, i]), (p_*OptionValue[1:i,
i+1] + q_*OptionValue[2:(i+1), i+1])/exp(r*dt));
    #}
    #for Lookback Options:
    OptionValue[1:2^(i-1), i] <- (p_*OptionValue[seq(1, 2^i, 2), i+1] +
q_*OptionValue[seq(2, 2^i, 2), i+1])/exp(r*dt);
  }

  result <- list("AssetPrice" = AssetPrice, "OptionValue" = OptionValue, "time" =
time);

  return(result);
}

S0 = 100;
K = 100;
t = 1;
M = 10;
r = 0.08;
vol = 0.2;

cat("Set 1.\n");
cat("Initial call option price =", (binopt( S0, K, r, t, M, vol, 1 , 'a' )$OptionValue)
[1,1], ".\n");
cat("Initial put option price =", (binopt( S0, K, r, t, M, vol, 0 , 'a' )$OptionValue)
[1,1], ".\n");

cat("Set 2.\n");
cat("Initial call option price =", (binopt( S0, K, r, t, M, vol, 1 , 'b' )$OptionValue)
[1,1], ".\n");
cat("Initial put option price =", (binopt( S0, K, r, t, M, vol, 0 , 'b' )$OptionValue)
[1,1], ".\n");

##Part a.
S0 = 91:110;
a1c <- 1:length(S0); a1p <- 1:length(S0);
a2c <- 1:length(S0); a2p <- 1:length(S0);

for (i in 1:length(S0)) {
  a1c[i] <- (binopt( S0[i], K, r, t, M, vol, 1 , 'a' )$OptionValue)[1,1];
  a1p[i] <- (binopt( S0[i], K, r, t, M, vol, 0 , 'a' )$OptionValue)[1,1];
  a2c[i] <- (binopt( S0[i], K, r, t, M, vol, 1 , 'b' )$OptionValue)[1,1];
  a2p[i] <- (binopt( S0[i], K, r, t, M, vol, 0 , 'b' )$OptionValue)[1,1];
}
pdf("2a.pdf");
par(mfrow=c(2,2));
plot(S0,a1c, main="Call option for Set1", sub="S(0) vs. Initial Price",
     xlab="S0", ylab="Initial Price");
plot(S0,a1p, main="Put option for Set1", sub="S(0) vs. Initial Price",
```

```
     xlab="S0", ylab="Initial Price");
plot(S0,a2c, main="Call option for Set2", sub="S(0) vs. Initial Price",
     xlab="S0", ylab="Initial Price");
plot(S0,a2p, main="Put option for Set2", sub="S(0) vs. Initial Price",
     xlab="S0", ylab="Initial Price");

dev.off();

S0 = 100;
#*#

##Part b.
K = 91:110;
b1c <- 1:length(K); b1p <- 1:length(K);
b2c <- 1:length(K); b2p <- 1:length(K);

for (i in 1:length(K)) {
  b1c[i] <- (binopt( S0, K[i], r, t, M, vol, 1 , 'a' )$OptionValue)[1,1];
  b1p[i] <- (binopt( S0, K[i], r, t, M, vol, 0 , 'a' )$OptionValue)[1,1];
  b2c[i] <- (binopt( S0, K[i], r, t, M, vol, 1 , 'b' )$OptionValue)[1,1];
  b2p[i] <- (binopt( S0, K[i], r, t, M, vol, 0 , 'b' )$OptionValue)[1,1];
}

pdf("2b.pdf");
par(mfrow=c(2,2));
plot(K,b1c, main="Call option for Set1", sub="K vs. Initial Price",
     xlab="K", ylab="Initial Price");
plot(K,b1p, main="Put option for Set1", sub="K vs. Initial Price",
     xlab="K", ylab="Initial Price");
plot(K,b2c, main="Call option for Set2", sub="K vs. Initial Price",
     xlab="K", ylab="Initial Price");
plot(K,b2p, main="Put option for Set2", sub="K vs. Initial Price",
     xlab="K", ylab="Initial Price");

dev.off();

K = 100;
#*#

##Part c.
r = seq(0.05, 0.15, by=0.01);
c1c <- 1:length(r); c1p <- 1:length(r);
c2c <- 1:length(r); c2p <- 1:length(r);

for (i in 1:length(r)) {
  c1c[i] <- (binopt( S0, K, r[i], t, M, vol, 1 , 'a' )$OptionValue)[1,1];
  c1p[i] <- (binopt( S0, K, r[i], t, M, vol, 0 , 'a' )$OptionValue)[1,1];
  c2c[i] <- (binopt( S0, K, r[i], t, M, vol, 1 , 'b' )$OptionValue)[1,1];
  c2p[i] <- (binopt( S0, K, r[i], t, M, vol, 0 , 'b' )$OptionValue)[1,1];
}

pdf("2c.pdf");
par(mfrow=c(2,2));
plot(r,c1c, main="Call option for Set1", sub="r vs. Initial Price",
     xlab="r", ylab="Initial Price");
plot(r,c1p, main="Put option for Set1", sub="r vs. Initial Price",
     xlab="r", ylab="Initial Price");
plot(r,c2c, main="Call option for Set2", sub="r vs. Initial Price",
     xlab="r", ylab="Initial Price");
plot(r,c2p, main="Put option for Set2", sub="r vs. Initial Price",
     xlab="r", ylab="Initial Price");

dev.off();
```

```
r = 0.08;
#*#

##Part d.
vol = seq(0.05, 0.35, by=0.01);
d1c <- 1:length(vol); d1p <- 1:length(vol);
d2c <- 1:length(vol); d2p <- 1:length(vol);

for (i in 1:length(vol)) {
  d1c[i] <- (binopt( S0, K, r, t, M, vol[i], 1 , 'a' )$OptionValue)[1,1];
  d1p[i] <- (binopt( S0, K, r, t, M, vol[i], 0 , 'a' )$OptionValue)[1,1];
  d2c[i] <- (binopt( S0, K, r, t, M, vol[i], 1 , 'b' )$OptionValue)[1,1];
  d2p[i] <- (binopt( S0, K, r, t, M, vol[i], 0 , 'b' )$OptionValue)[1,1];
}

pdf("2d.pdf");
par(mfrow=c(2,2));
plot(vol,d1c, main="Call option for Set1", sub="vol vs. Initial Price",
     xlab="vol", ylab="Initial Price");
plot(vol,d1p, main="Put option for Set1", sub="vol vs. Initial Price",
     xlab="vol", ylab="Initial Price");
plot(vol,d2c, main="Call option for Set2", sub="vol vs. Initial Price",
     xlab="vol", ylab="Initial Price");
plot(vol,d2p, main="Put option for Set2", sub="vol vs. Initial Price",
     xlab="vol", ylab="Initial Price");

dev.off();

vol = 0.2;
#*#

##Part e.
M = seq(5, 15, by=1);
e1c_k95 <- 1:length(M); e1c_k100 <- 1:length(M); e1c_k105 <- 1:length(M);
e1p_k95 <- 1:length(M); e1p_k100 <- 1:length(M); e1p_k105 <- 1:length(M);
e2c_k95 <- 1:length(M); e2c_k100 <- 1:length(M); e2c_k105 <- 1:length(M);
e2p_k95 <- 1:length(M); e2p_k100 <- 1:length(M); e2p_k105 <- 1:length(M);

for (i in 1:length(M)) {
  e1c_k95[i] <- (binopt( S0, 95, r, t, M[i], vol, 1 , 'a' )$OptionValue)[1,1];
  e1p_k95[i] <- (binopt( S0, 95, r, t, M[i], vol, 0 , 'a' )$OptionValue)[1,1];
  e2c_k95[i] <- (binopt( S0, 95, r, t, M[i], vol, 1 , 'b' )$OptionValue)[1,1];
  e2p_k95[i] <- (binopt( S0, 95, r, t, M[i], vol, 0 , 'b' )$OptionValue)[1,1];

  e1c_k100[i] <- (binopt( S0, 100, r, t, M[i], vol, 1 , 'a' )$OptionValue)[1,1];
  e1p_k100[i] <- (binopt( S0, 100, r, t, M[i], vol, 0 , 'a' )$OptionValue)[1,1];
  e2c_k100[i] <- (binopt( S0, 100, r, t, M[i], vol, 1 , 'b' )$OptionValue)[1,1];
  e2p_k100[i] <- (binopt( S0, 100, r, t, M[i], vol, 0 , 'b' )$OptionValue)[1,1];

  e1c_k105[i] <- (binopt( S0, 105, r, t, M[i], vol, 1 , 'a' )$OptionValue)[1,1];
  e1p_k105[i] <- (binopt( S0, 105, r, t, M[i], vol, 0 , 'a' )$OptionValue)[1,1];
  e2c_k105[i] <- (binopt( S0, 105, r, t, M[i], vol, 1 , 'b' )$OptionValue)[1,1];
  e2p_k105[i] <- (binopt( S0, 105, r, t, M[i], vol, 0 , 'b' )$OptionValue)[1,1];
}

pdf("2e_k95.pdf");
par(mfrow=c(2,2));
plot(M,e1c_k95, main="Call option for Set1 with K=95", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");
plot(M,e1p_k95, main="Put option for Set1 with K=95", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");
plot(M,e2c_k95, main="Call option for Set2 with K=95", sub="M vs. Initial Price",
```

```
     xlab="M", ylab="Initial Price");
plot(M,e2p_k95, main="Put option for Set2 with K=95", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");

dev.off();

pdf("2e_k100.pdf");
par(mfrow=c(2,2));
plot(M,e1c_k100, main="Call option for Set1 with K=100", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");
plot(M,e1p_k100, main="Put option for Set1 with K=100", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");
plot(M,e2c_k100, main="Call option for Set2 with K=100", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");
plot(M,e2p_k100, main="Put option for Set2 with K=100", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");

dev.off();

pdf("2e_k105.pdf");
par(mfrow=c(2,2));
plot(M,e1c_k105, main="Call option for Set1 with K=105", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");
plot(M,e1p_k105, main="Put option for Set1 with K=105", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");
plot(M,e2c_k105, main="Call option for Set2 with K=105", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");
plot(M,e2p_k105, main="Put option for Set2 with K=105", sub="M vs. Initial Price",
     xlab="M", ylab="Initial Price");

dev.off();

M = 100;
#*#

rm(list = ls())
```