Complete within two working days

Third Year B.S. Honours (Session: 2022-2023)

Department of Applied Mathematics, University of Dhaka

Course Title: Math Lab III (MATLAB), Course No.: AMTH 350

Assignment 06

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Instructions

1. Create a folder in **Third year drive** and rename it as your **Class Roll**.
2. All of your tasks must be stored in the newly created folder.
3. Solve each of the following problems using MATLAB.
4. Use Excel/Notepad files for any kind of input and output unless specified otherwise.

1. Suppose that USD spot and forward exchange rates are as follows:

Spot	1.4580
90-day forward	1.4556
180-day forward	1.4518

What opportunities are open to an arbitrageur in the following situations?

(i) A 180-day European call option to buy 1 for \$1.42 costs 2 cents.

(ii) A 90-day European put option to sell 1 for \$1.49 costs 2 cents.

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2. Write a function for the call and put options payoff.
   (a) Draw the payoff diagram of a long call, short call, long put and short put on the same diagram with different legends.
   (b) Draw the profit diagram of a long call, short call, long put and short put using subplots.

3. Draw some figures to show the effect on the price of a stock option with the following:
   (a) current stock price, S_0.
   (b) strike price, K.
   (c) volatility, σ.

4. A stock price is currently 20 BDT. It is known that at the end of 3 months it will be either 22 BDT or 18 BDT. The risk-free rate of interest with continuous compounding is 12% per annum. Calculate the value of a 3-month European call option on the stock with an exercise price of 21 BDT. Verify that no-arbitrage arguments and risk-neutral valuation arguments give the same answers.

5. A stock price is currently 30 BDT. During each 2 months for the next 4 months, it will increase by 8% or reduce by 10%. The risk-free interest rate is 5% per annum. Use a two-step tree to calculate the value of a derivative (American-style) that pays off $[\max(30 - S_T, 0)]^2$, where S_T is the stock price in 4 months.

6. Call options on a stock are available with strike prices of 15 BDT, 17.5 BDT, and 20 BDT, and expiration dates in 3 months. Their prices are 4 BDT, 2 BDT, and 0.5 BDT, respectively. Now draw a Payoff and Profit diagram of the butterfly spread.

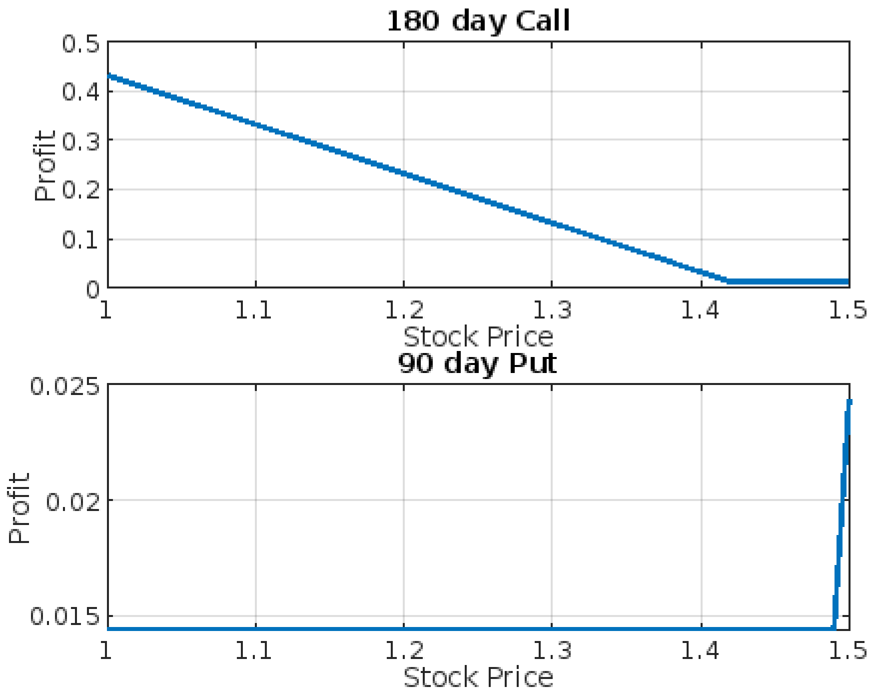
7. Call and Put options on a stock are available with strike prices of 15 BDT and expiration dates in 3 months. Their prices are 2 BDT and 1 BDT, respectively. Now draw a Payoff diagram of the strip and strap.

8. Consider an American call option on a stock when there are ex-dividend dates in two months and five months. The dividend on each ex-dividend date is expected to be 0.50 BDT. The current share price is 40 BDT, the exercise price is 40 BDT, the stock price volatility is 30% per annum, the risk-free rate of interest is 9% per annum, and the time to maturity is six months. Find the call option price.

– The End –

```
spot=1.4580;
ninety_forward=1.4556;
oneeighty_forward=1.4518;
strike_call=1.42;
strike_put=1.49;
option=0.02;
S=linspace(1,1.5,50);
profit_call=max(S-strike_call,0)-option+1.4518-S;
profit_put=max(strike_put-S,0)-option+S-1.4556;
disp('minimum profit for 180 day long call: ')
p1=min(profit_call)
disp('minimum profit for 90 day long put: ')
p2=min(profit_put)
figure;
subplot(2,1,1)
plot(S,profit_call,'LineWidth',2)
xlabel('Stock Price')
ylabel('Profit')
title('180 day Call')
grid on;
subplot(2,1,2)
plot(S,profit_put,'LineWidth',2)
xlabel('Stock Price')
ylabel('Profit')
title('90 day Put')
grid on;
```

```
minimum profit for 180 day long call:

p1 =

    0.0118

minimum profit for 90 day long put:

p2 =

    0.0144
```



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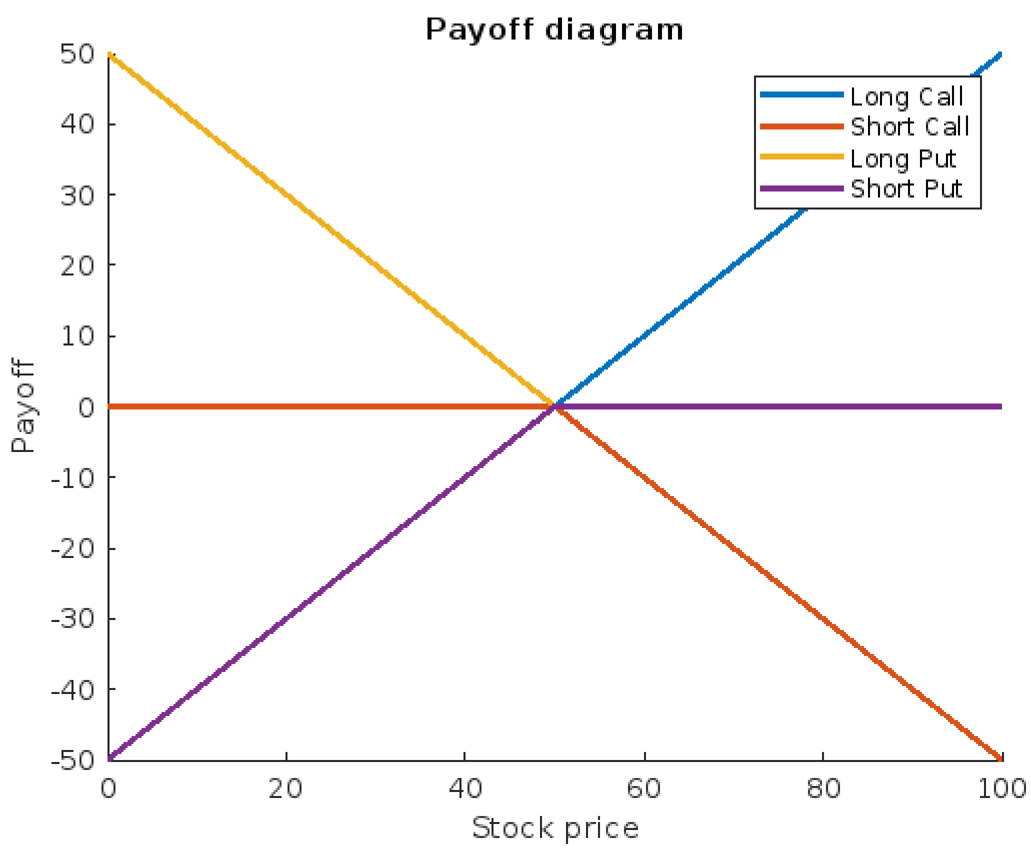
```
%a6q2a
s=0:1:100;
k=50;
longcallpayoff=max(s-k,0);
shortcallpayoff=-max(s-k,0);
longputpayoff=max(k-s,0);
shortputpayoff=-max(k-s,0);
hold on;
plot(s,longcallpayoff,'LineWidth',2);
plot(s,shortcallpayoff,'LineWidth',2);
plot(s,longputpayoff,'LineWidth',2);
plot(s,shortputpayoff,'LineWidth',2);
hold off;
legend('Long Call','Short Call','Long Put','Short Put');
xlabel('Stock price');
ylabel('Payoff');
title('Payoff diagram');
```



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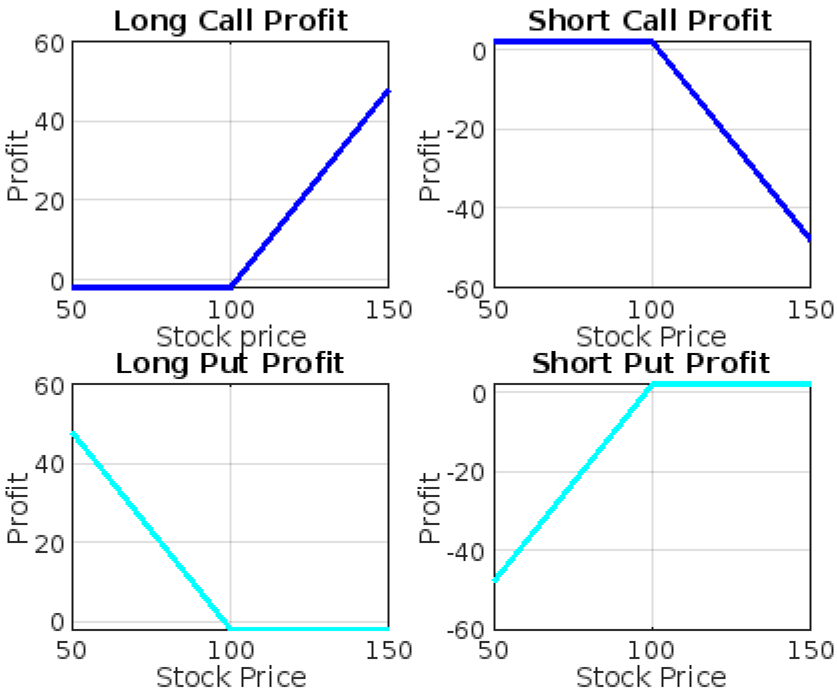
```
clc;clear all;
s=50:1:150;
k=100;
c=2;
p=2;
longcallprofit=max(s-k,0)-c;
shortcallprofit=-max(s-k,0)+c;
longputprofit=max(k-s,0)-p;
shortputprofit=-max(k-s,0)+p;
figure;
subplot(2,2,1)
plot(s,longcallprofit,'b','LineWidth',2)
xlabel('Stock price')
ylabel('Profit')
title('Long Call Profit')
grid on;
subplot(2,2,2)
plot(s,shortcallprofit,'b','LineWidth',2)
xlabel('Stock Price')
ylabel('Profit')
title('Short Call Profit')
grid on;
subplot(2,2,3)
plot(s,longputprofit,'c','LineWidth',2)
xlabel('Stock Price')
ylabel('Profit')
title('Long Put Profit')
grid on;
subplot(2,2,4)
plot(s,shortputprofit,'c','LineWidth',2)
xlabel('Stock Price')
ylabel('Profit')
title('Short Put Profit')
grid on;
```



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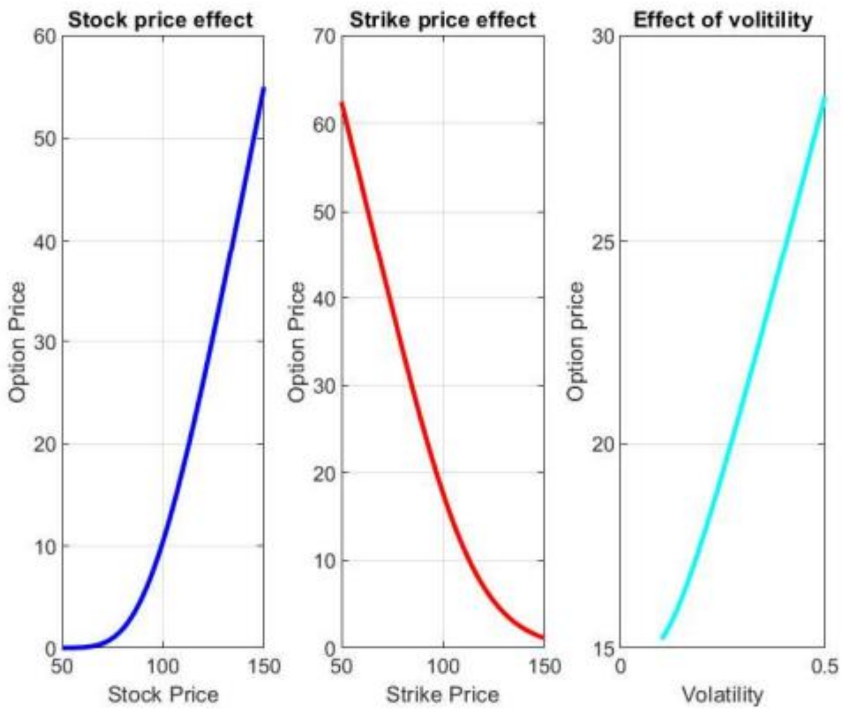
```
s0=110;k=100;r=0.05; T=1; sigma=0.2;
 s_range=50:1:150;
k_range=50:1:150;
sigma_range=0.1:0.01:.5;
 option_price_s=zeros(size(s_range));
for i=1:length(s_range)
option_price_s(i)=blsprice(s_range(i),k,r,T,sigma);
 end
for i=1:length(k_range)
option_price_k(i)=blsprice(s0,k_range(i),r,T,sigma);
end
for i=1:length(sigma_range)
 option_price_sigma(i)=blsprice(s0,k,r,T,sigma_range(i));
end
 figure;
 subplot(1,3,1) plot(s_range,option_price_s,'b','LineWidth',2)
 xlabel('Stock Price')
ylabel('Option Price')
 title('Effect of stock price on option price')
 grid on;
 subplot(1,3,2)
plot(k_range,option_price_k,'r','LineWidth',2)
xlabel('Strike Price')
```


Stock price effect
Option Price
Stock Price
Strike price effect
Option Price
Strike Price
Effect of volitility
Option price
Volatility

```
s=20;
k=21;
r=0.12;
T=0.25;
sd=18;
su=22;
u=su/s;
d=sd/s;
fu=max(su-k,0);
fd=max(sd-k,0);
delta=(fu-fd)/(s*(u-d));
f_na=(s*delta)-((s*u*delta-fu)*exp(-r*T));
p=(exp(r*T)-d)/(u-d);
f_rnv=(p*fu+(1-p)*fd)*exp(-r*T);
disp('No arbitrage: ')
disp(f_na);
disp('Risk-neutral valuation:')
disp(f_rnv);
if ((f_na-f_rnv)<10^-5)
 disp('Both the arguments give the same answers')
end
```

```
No arbitrage:
    0.6330

Risk-neutral valuation:
    0.6330

Both the arguments give the same answers
```

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```
S=30;
k=30;
T=4/12;
dt=T/2;
u=1+0.08;
d=1-0.1;
r=0.05;
Su=S*u;
Sd=S*d;
Suu=S*u^2;
Sud=S*u*d;
Sdd=S*d^2;
f_uu=max(k-Suu,0)^2;
f_ud=max(k-Sud,0)^2;
f_dd=max(k-Sdd,0)^2;
p=(exp(r*dt)-d)/(u-d);
fu=max(exp(-r*dt)*(p*f_uu+(1-p)*f_ud),max(k-Su,0)^2);
fd=max(exp(-r*dt)*(p*f_ud+(1-p)*f_dd),max(k-Sd,0)^2);
f=exp(-r*dt)*(p*fu+(1-p)*fd);
fprintf('The value of the derivative for the American Put Option: %5.4f \n',f)
```

```
The value of the derivative for the American Put Option: 5.3928
```

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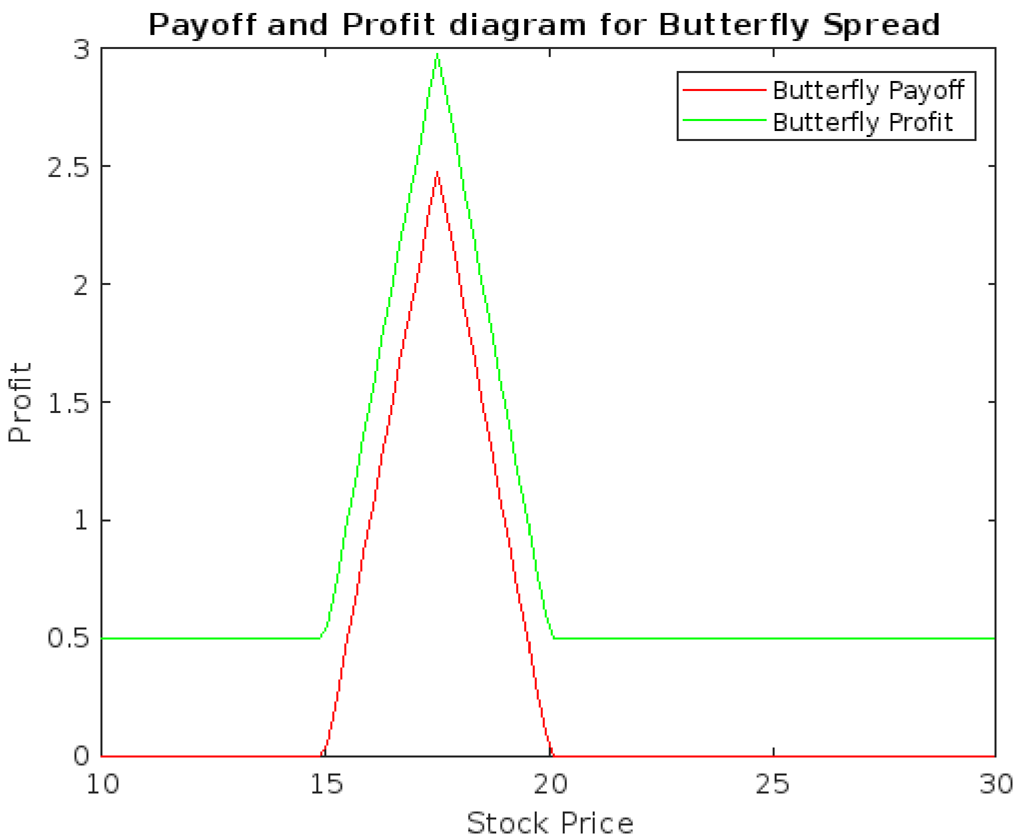
```
k1=15;
k2=17.5;
k3=20;
T=0.25;
c1=4;
c2=2;
c3=0.5;
S=linspace(10,30,100);
long_call_k1=max(S-k1,0);
short_call=-max(S-k2,0);
long_call_k3=max(S-k3,0);
lc_profit1=max(S-k1,0)-c1;
sc_profit2=-max(S-k2,0)+c2;
lc_profit3=max(S-k3,0)+c3;
bfly_payoff=long_call_k1+long_call_k3+2*short_call;
plot(S,bfly_payoff,'r')
hold on;
bfly_profit=lc_profit1+lc_profit3+2*sc_profit2;
plot(S,bfly_profit,'g')
xlabel('Stock Price')
ylabel('Profit')
legend('Butterfly Payoff','Butterfly Profit')
title('Payoff and Profit diagram for Butterfly Spread ')
```



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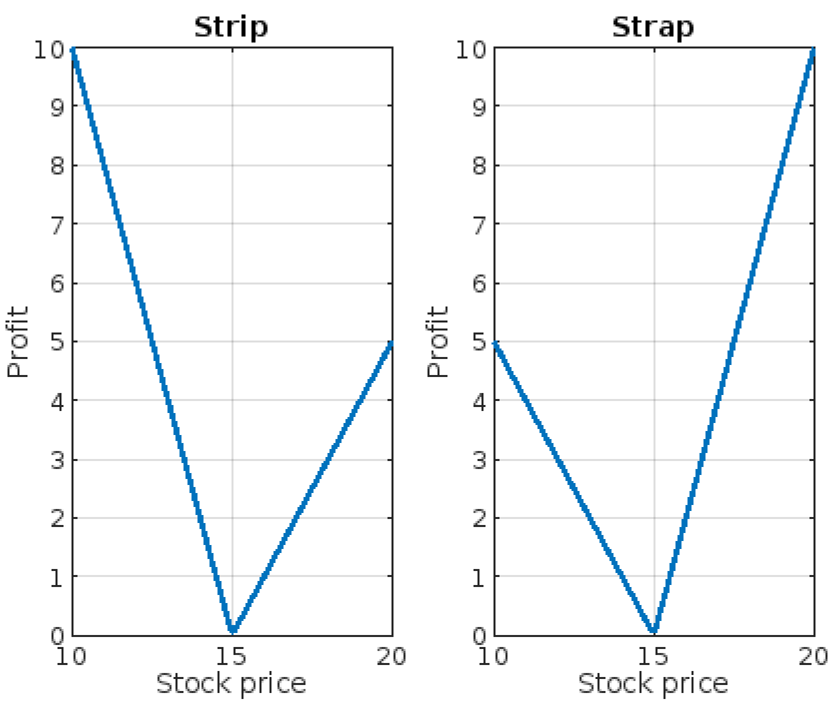
```
clc;clear all;
k=15;
S=linspace(10,20,100);
long_call=max(S-k,0);
long_put=max(k-S,0);
strip_portfolio=long_call+2*long_put;
stap_portfolio=2*long_call+long_put;
figure;
subplot(1,2,1)
plot(S,strip_portfolio,'LineWidth',2)
xlabel('Stock price')
ylabel('Profit')
title('Strip')
grid on;
subplot(1,2,2)
plot(S,stap_portfolio,'LineWidth',2)
xlabel('Stock price')
ylabel('Profit')
title('Strap')
grid on;
```



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```
clc
clear all
clearvars

S0=40;
K=40;
t=[2 5].*(1/12);
sg=30*(1/100);
r=9*(1/100);
T=6*(1/12);
S=S0;
D=[0.5 0.5];
dsum=0;

for i=1:numel(D)
    dsum=dsum+D(i)*exp(-r*t(i));
end
S=S-dsum;
d1=(log(S/K)+(r+((sg^2)/2))*T)/(sg*sqrt(T));
d2=d1-sg*sqrt(T);
c1=S*normcdf(d1)-K*exp(-r*T)*normcdf(d2);

t=[t T];
t_exercise=T;
S=S0;
dsum=0;
for i=1:numel(D)
   if D(i)> K*(1-exp(-r*(t(i+1)-t(i))))
       t_exercise=t(i);
       break;
   end
   dsum=dsum+D(i)*exp(-r*t(i));
end
S=S-dsum;
d1=(log(S/K)+(r+((sg^2)/2))*t_exercise)/(sg*sqrt(t_exercise));
d2=d1-sg*sqrt(t_exercise);
c2=S*normcdf(d1)-K*exp(-r*t_exercise)*normcdf(d2);


fprintf('Black-Scholes'' approximation for the American Call option
is       :  %7.4f\n',max(c1,c2))

fprintf('The option should be exercised just before ex-dividend date :%4d
months',t_exercise*12)
```

Black-Scholes' approximation for the American Call option is   :   3.6712
The option should be exercised just before ex-dividend date :   5 months

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