Praveen Kumar Yadav

(MTech VLSI Sem 1, EE22M308)

Lab no. : 3

Used version: Matlab 2022

Q.1:- Assume two metal plates A and B are kept at a separation of 100mm in free space. Plate A is grounded (at x=0) and while plate B is held at a potential of 1V (at x=100 mm). Find the potential profile from Plate A to Plate B. Obtain the results using the analytical methods as well as numerical methods. Compare the results obtained using both the methods.

ANS:

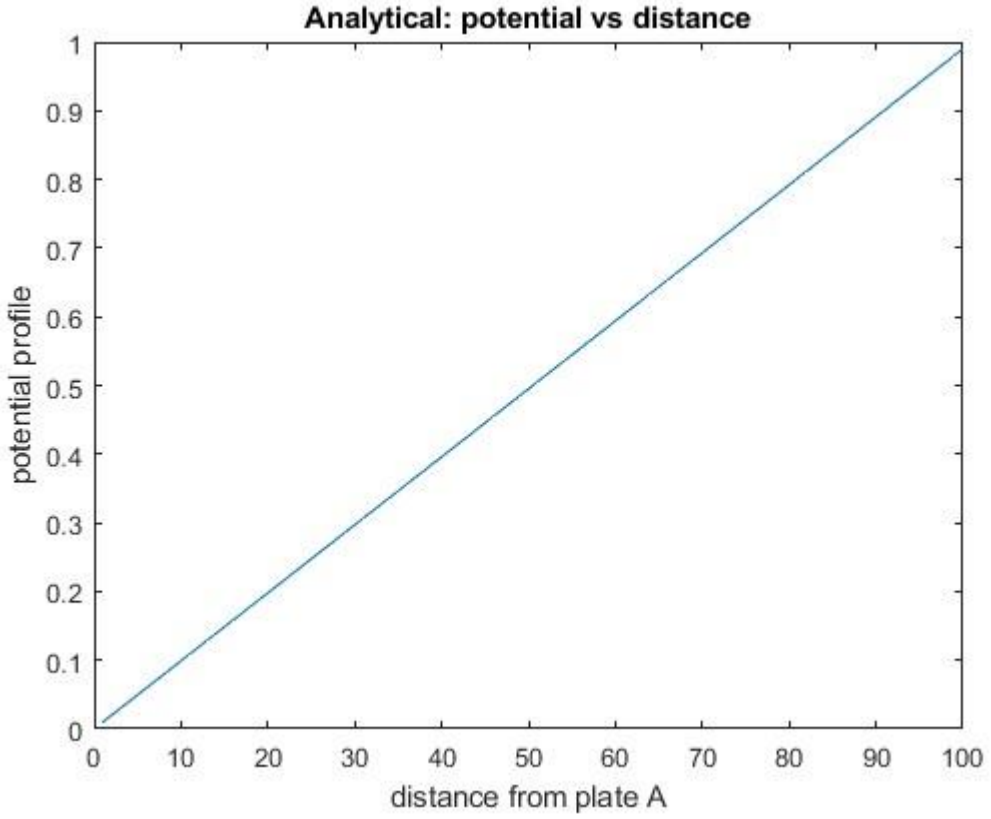
Code:

Numerical:

```
clc;
 clear all;
   close all;
   response =[];
   iter = [];
   % analytical
%    for i=1:100
%        v=i/100;
%        response = [response v];
%        iter = [iter i];
%    end
   %plot(iter, response);
% numerical
for i=1:100
    H(i,i)=-2;
end
for i=1:99
    H(i+1,i)=1;
end
for i=1:99
    H(i,i+1)=1;
end
A=zeros(100,1);
```

```
A(100,1)=-1;
v=(inv(H)*A);
plot (v);
```

xlabel('distance from plate A');
ylabel('potential profile');
title('Analytical: potential vs distance');



Analytical:
ANS:

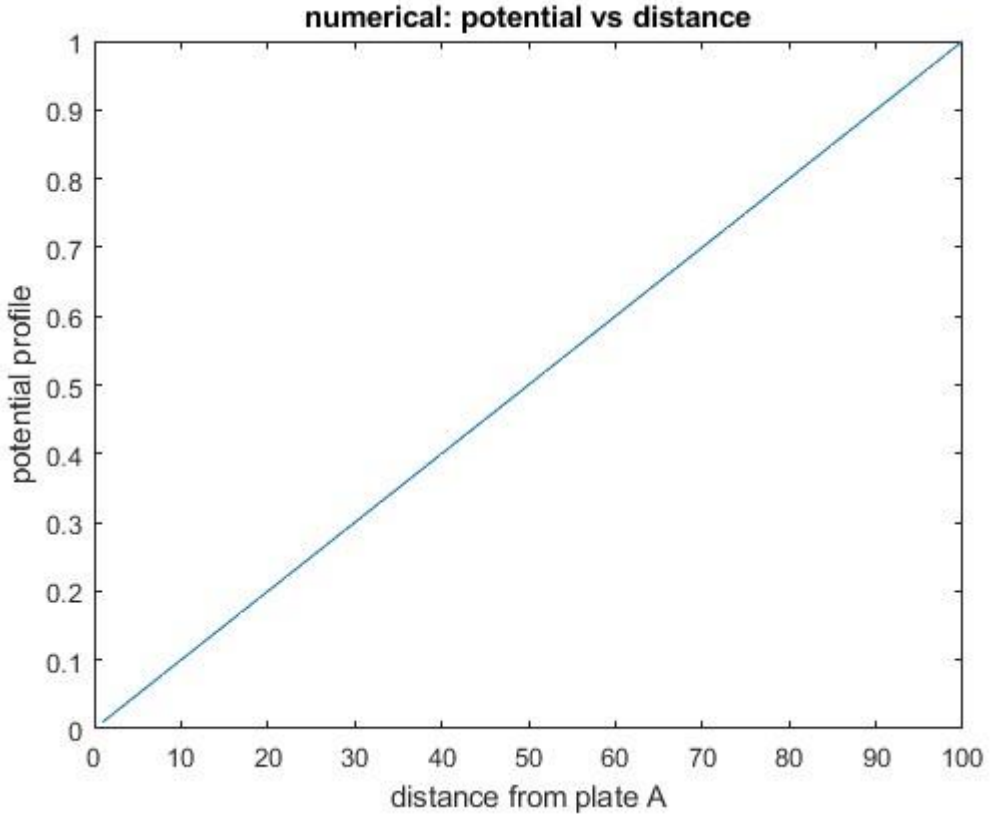
Code:

Numerical:

```
clc;
 clear all;
   close all;
   response =[];
   iter = [];
   % analytical
%    for i=1:100
%        v=i/100;
%        response = [response v];
%        iter = [iter i];
%    end
   %plot(iter, response);
% numerical
```

```
for i=1:100
    H(i,i)=-2;
end
for i=1:99
    H(i+1,i)=1;
end
for i=1:99
    H(i,i+1)=1;
end
A=zeros(100,1);
A(100,1)=-1;
v=(inv(H)*A);
plot (v);
```

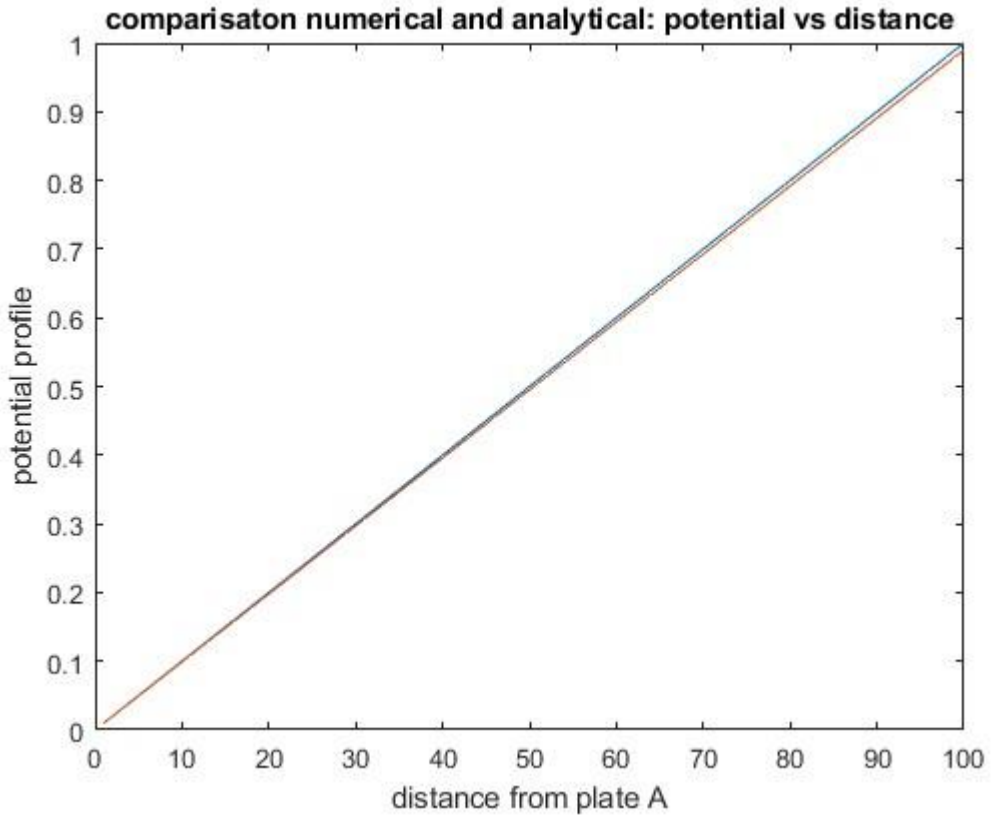
xlabel('distance from plate A');
ylabel('potential profile');
title('numerical: potential vs distance');



Comparision:

```
clc;
 clear all;
   close all;
   response =[];
   iter = [];
   % analytical
   for i=1:100
       v=i/100;
       response = [response v];
```

```
        iter = [iter i];
    end
    %plot(iter, response);
% numerical
for i=1:100
    H(i,i)=-2;
end
for i=1:99
    H(i+1,i)=1;
end
for i=1:99
    H(i,i+1)=1;
end
A=zeros(100,1);
A(100,1)=-1;
v=(inv(H)*A);
i=1:100;
plot (iter, response, i, v);
xlabel('distance from plate A');
ylabel('potential profile');
title('comparisaton numerical and analytical: potential vs distance');
```



Q.2:- For the same configuration as above, assume both plates are grounded, and a charge sheet of zero thickness but with charge of 10-6C/cm2

is placed at a distance of

30mm from plate A towards plate B. Find the potential profile from Plate A to Plate B.

Obtain the results using the analytical methods as well as numerical methods. Compare

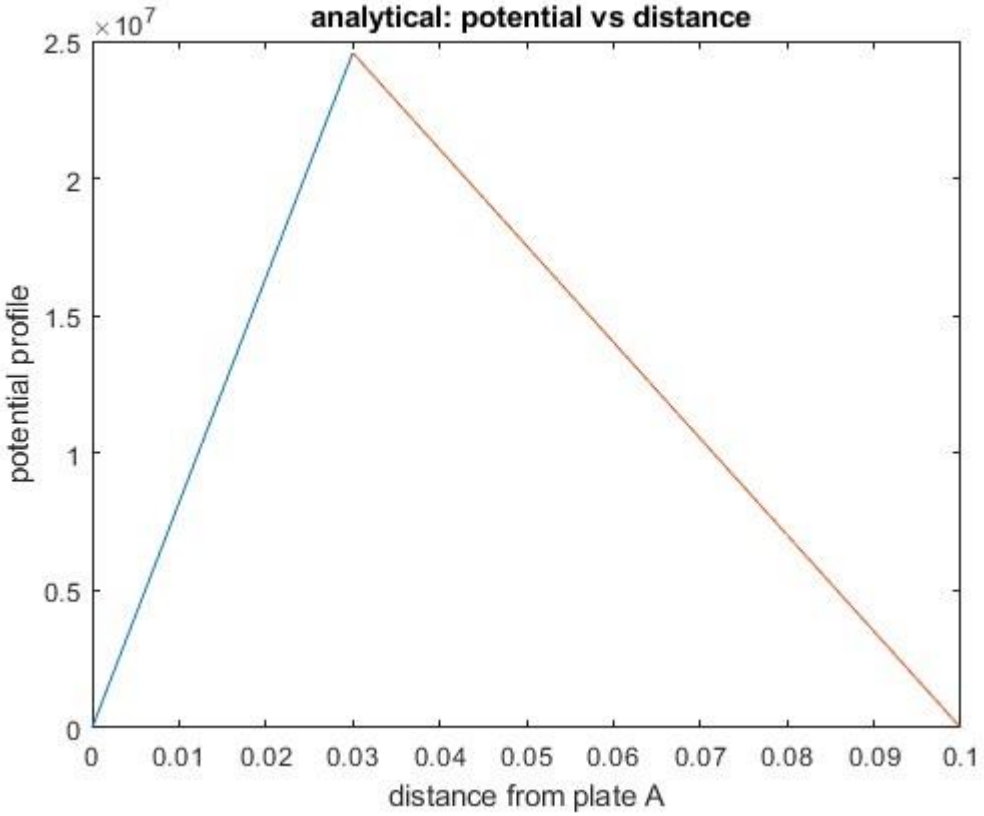
the results obtained using both the methods.

Ans:

Analytical:

```
clc;
 clear all;
   close all;
%    response1 =[];
%    iter1 = [];
%     response2 =[];
%    iter2 = [];
%    sigma=10^(-2);
%    dx=0.1/99;
%    epsilon=8.85*(10)^(-12);

   %analytical
x1=0:0.01:0.03;
f1=0.819*(10^9)*x1;
x2=0.03:0.01:0.1;
f2=-(0.351)*(10^9)*(x2-0.1);
plot(x1,f1,x2,f2);
%numerical
% for i=1:100
%     H(i,i)=-2;
% end
% for i=1:99
%     H(i+1,i)=1;
% end
% for i=1:99
%     H(i,i+1)=1;
% end
% A=zeros(100,1);
% A(30,1)=-((sigma*dx)/epsilon);
% v=(inv(H)*A);
% plot (v);
xlabel('distance from plate A');
ylabel('potential profile');
title(' analytical: potential vs distance');
```

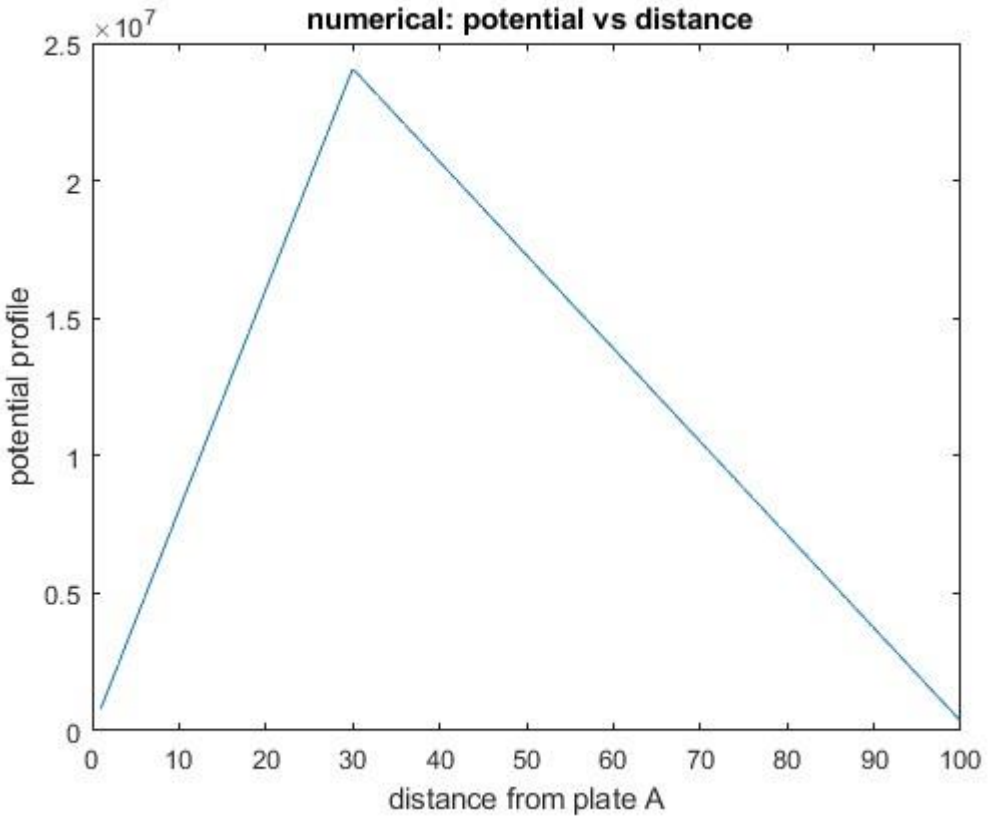


Numerical:

```
clc;
 clear all;
   close all;
   response1 =[];
   iter1 = [];
    response2 =[];
   iter2 = [];
   sigma=10^(-2);
   dx=0.1/99;
   epsilon=8.85*(10)^(-12);

   %analytical
% x1=0:0.01:0.03;
% f1=0.819*(10^9)*x1;
% x2=0.03:0.01:0.1;
% f2=-(0.351)*(10^9)*(x2-0.1);
%plot(x1,f1,x2,f2);
%numerical
for i=1:100
    H(i,i)=-2;
end
for i=1:99
    H(i+1,i)=1;
end
for i=1:99
    H(i,i+1)=1;
end
```

```
A=zeros(100,1);
A(30,1)=-((sigma*dx)/epsilon);
v=(inv(H)*A);
plot (v);
xlabel('distance from plate A');
ylabel('potential profile');
title(' numerical: potential vs distance');
```

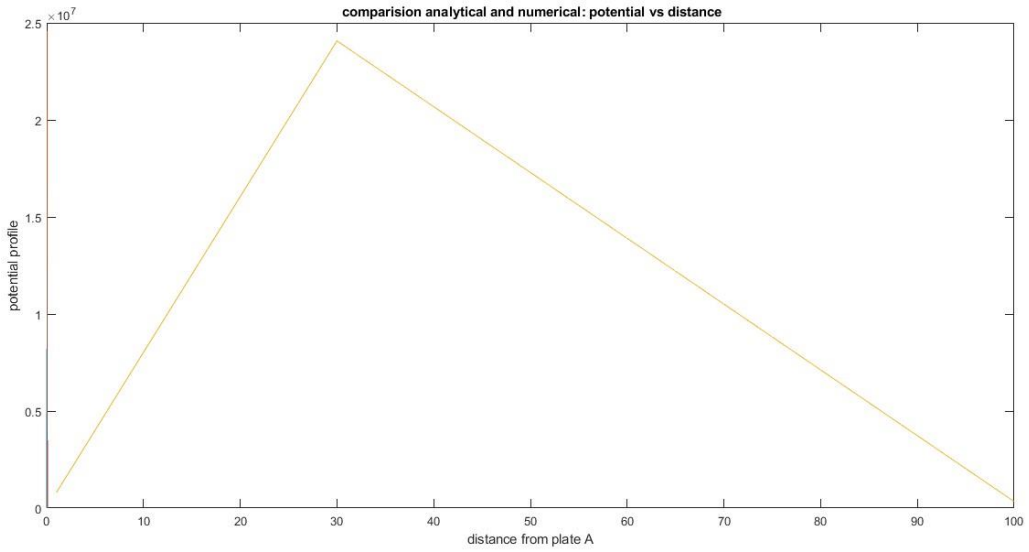


Comaparisation:

```
clc;
 clear all;
   close all;
   response1 =[];
   iter1 = [];
    response2 =[];
   iter2 = [];
   sigma=10^(-2);
   dx=0.1/99;
   epsilon=8.85*(10)^(-12);

   %analytical
x1=0:0.01:0.03;
f1=0.819*(10^9)*x1;
x2=0.03:0.01:0.1;
f2=-(0.351)*(10^9)*(x2-0.1);
%plot(x1,f1,x2,f2);
```

```
%numerical
for i=1:100
    H(i,i)=-2;
end
for i=1:99
    H(i+1,i)=1;
end
for i=1:99
    H(i,i+1)=1;
end
A=zeros(100,1);
A(30,1)=-((sigma*dx)/epsilon);
v=(inv(H)*A);
i=1:100;
plot (x1,f1,x2,f2,i,v);
xlabel('distance from plate A');
ylabel('potential profile');
title(' comparision analytical and numerical: potential vs distance');
```



Q.3:- For the problem (1), assume that the dielectric constant varies as a function of spatial co-ordinates as follows:

εr=1,0<x<30mm

εr=3,30<x<100mm

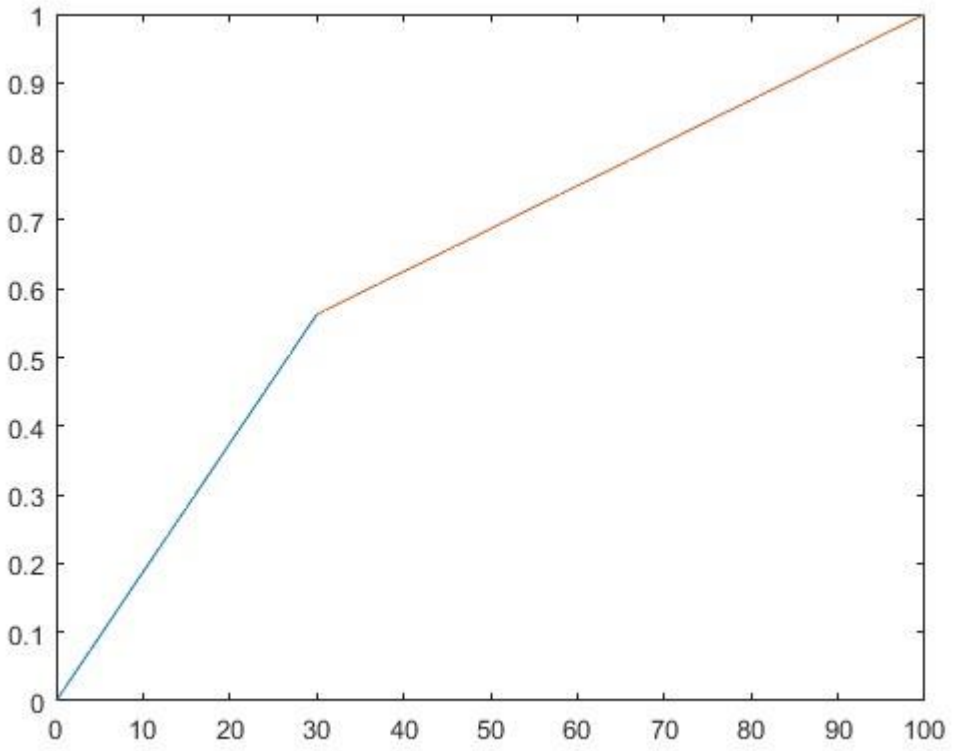
Find the potential profile from Plate A to Plate B and compare it with that of case (1). Obtain the results using the analytical methods as well as numerical methods. Compare the results obtained using both the methods.

ANS

Analytical:

```
clc;
 clear all;
   close all;
   response1 =[];
   iter1 = [];
    response2 =[];
   iter2 = [];
   sigma=10^(-2);
   dx=0.1/99;
   epsilon=8.85*(10)^(-12);
epsilon1=1;
epsilon2=3;

   %analytical
x1=0:1:30;
f1=(0.01875.*x1);
x2=30:1:100;
f2=((0.00625.*x2)+0.375);
plot(x1,f1, x2, f2);
%numerical
% for i=1:100
%        H(i,i)=-2;
% end
% for i=1:99
%     H(i+1,i)=1;
% end
% for i=1:99
%     H(i,i+1)=1;
% end
% H(30,29)=epsilon1*epsilon;
% H(30,30)=-(epsilon1+epsilon2)*epsilon;
% H(30,31)=epsilon2*epsilon;
% A=zeros(100,1);
% A(100,1)=-1;
% v=inv(H)*A;
% plot (v);
xlabel('distance from plate A');
ylabel('potential profile');
title('analytical: potential vs distance');
```

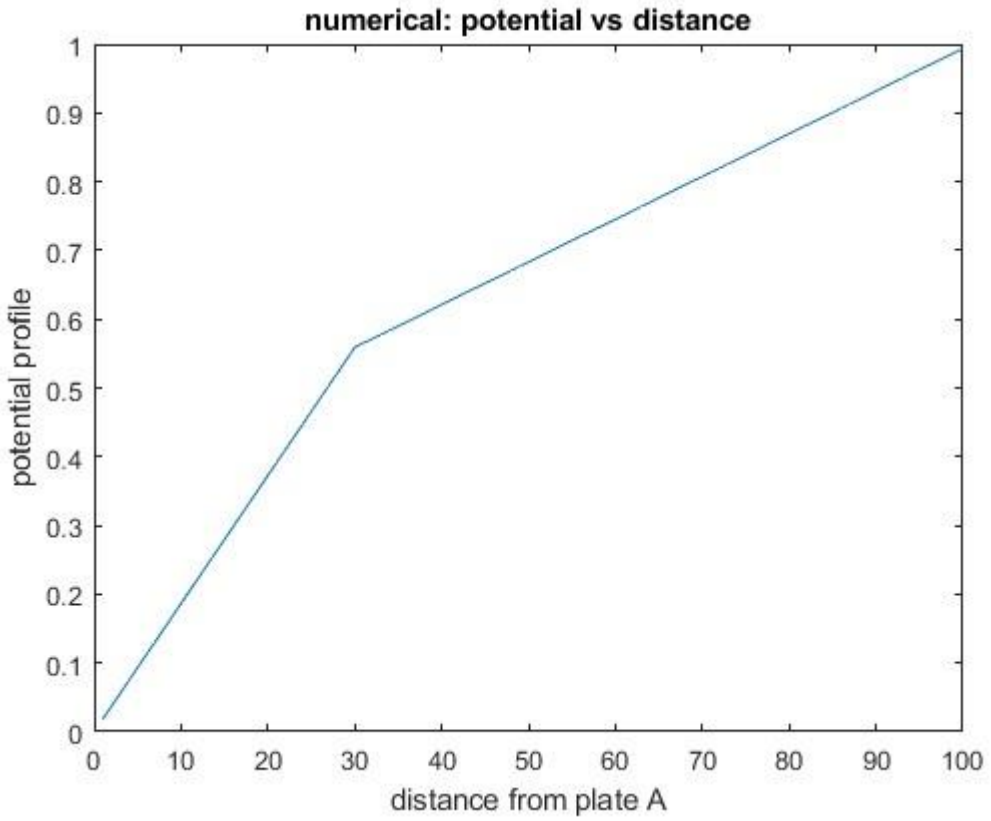


Numerical:

```
clc;
 clear all;
   close all;
   response1 =[];
   iter1 = [];
    response2 =[];
   iter2 = [];
   sigma=10^(-2);
   dx=0.1/99;
   epsilon=8.85*(10)^(-12);
epsilon1=1;
epsilon2=3;

   %analytical
% x1=0:1:30;
% f1=(0.01875.*x1);
% x2=30:1:100;
% f2=((0.00625.*x2)+0.375);
% plot(x1,f1, x2, f2);
%numerical
for i=1:100
       H(i,i)=-2;
end
for i=1:99
    H(i+1,i)=1;
```

```
end
for i=1:99
    H(i,i+1)=1;
end
H(30,29)=epsilon1*epsilon;
H(30,30)=-(epsilon1+epsilon2)*epsilon;
H(30,31)=epsilon2*epsilon;
A=zeros(100,1);
A(100,1)=-1;
v=inv(H)*A;
plot (v);
xlabel('distance from plate A');
ylabel('potential profile');
title('numerical: potential vs distance');
```

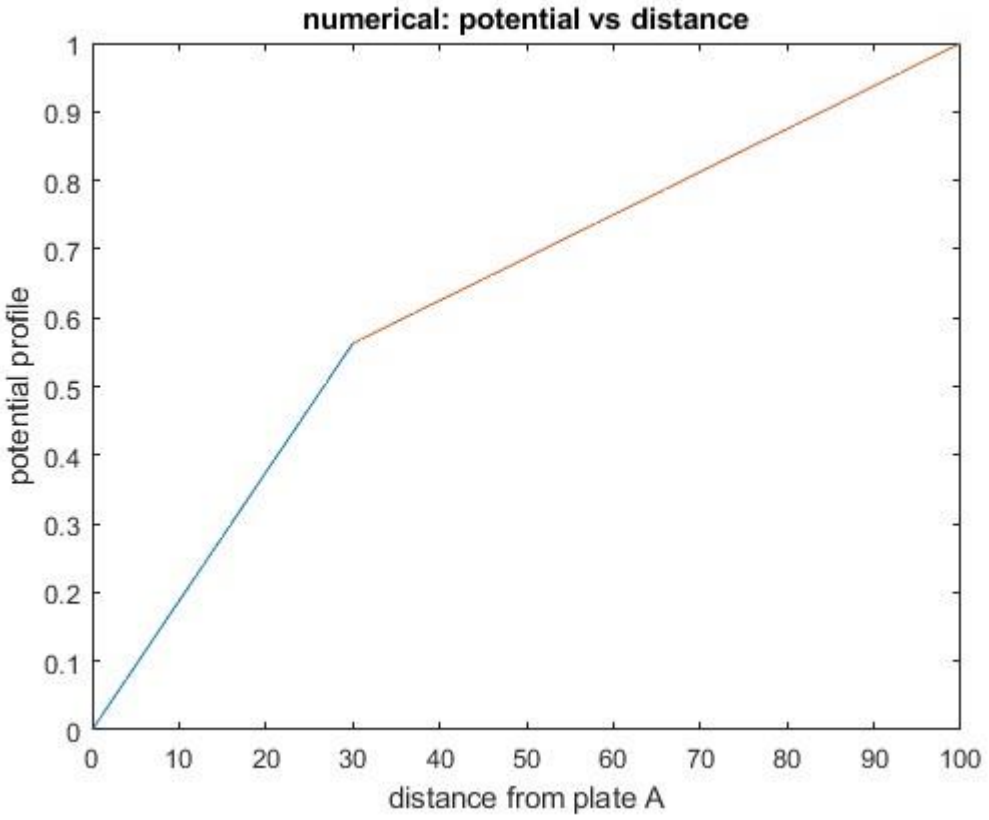


COMPARISION:

```
clc;
 clear all;
   close all;
   response1 =[];
   iter1 = [];
    response2 =[];
   iter2 = [];
   sigma=10^(-2);
   dx=0.1/99;
```

```
   epsilon=8.85*(10)^(-12);
epsilon1=1;
epsilon2=3;

   %analytical
x1=0:1:30;
f1=(0.01875.*x1);
x2=30:1:100;
f2=((0.00625.*x2)+0.375);
% plot(x1,f1, x2, f2);
%numerical
for i=1:100
       H(i,i)=-2;
end
for i=1:99
    H(i+1,i)=1;
end
for i=1:99
    H(i,i+1)=1;
end
H(30,29)=epsilon1*epsilon;
H(30,30)=-(epsilon1+epsilon2)*epsilon;
H(30,31)=epsilon2*epsilon;
A=zeros(100,1);
A(100,1)=-1;
v=inv(H)*A;
plot (x1,f1, x2, f2,i,v);
xlabel('distance from plate A');
ylabel('potential profile');
title('numerical: potential vs distance');
```



Q.4:- Assuming the conditions in case (1), assume that the region between A and B has a charge density of q×1016 cm-3, where q is the electronic charge. Find the potential profile between the plates A and B. Obtain the results using the analytical methods as
well as numerical methods. Compare the results obtained using both the methods.
Ans
Numerical and analytical and comparisation:

```
n = input("enter the value of points for discretization");
w = 100;
M = [];
C = [];
V = [];
y = [];
k = (1.6)/8.85;
x = 0:1:100;
y = (-k/2)*x.^2 + (50*k + .01)*x;
for i=1:n
    for j=1:n
        if j==i
        M(i,j) = -2;
        elseif j==i-1 ||  j==i+1
            M(i,j) = 1;
        else
            M(i,j)=0;
        end
        if i == n
            C(i) = -1;
        else
```

```
            C(i) =-1*k ;
        end
    end

end
tr_c = transpose(C);
inv_M = inv(M);
V = inv_M*tr_c;
subplot(2,1,1)
plot(1:n,V)
xlabel('x')
 ylabel('Voltage')
 title('Voltage Profile using numerical method')
subplot(2,1,2)
plot(x,y)
xlabel('x')
 ylabel('Voltage')
 title('Voltage Profile Using Analytical method')
```