Mathematics II (5EMA0)
Second Optimization Assignment
Group Number: 3

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Scatter Plot:
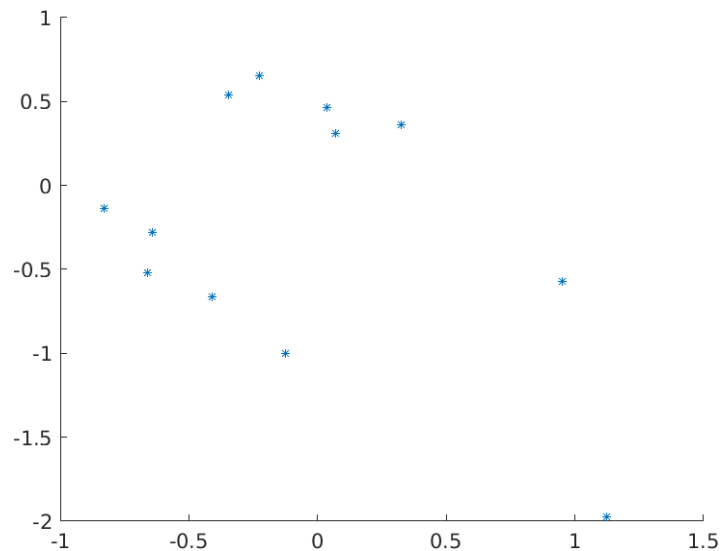
Initialisation Script:

```
g = 3;
rng(g);
n = 12;
x = random('Normal' , 0 , 1 , n , 1);
y = random('Normal' , 0 , 1 , n , 1);
scatter(x,y,n , '*');
%% Problem 1
% k = [-49, 0] -> k = [51 100]
for k = 1:100
    cosine = cos((2 * k * pi)/100) * x;
    sine = sin((2 * k * pi)/100) * y;
    A(k,:) = exp(j *(cosine + sine));
end
```

Problem 1:

1.1)

CVX Script:
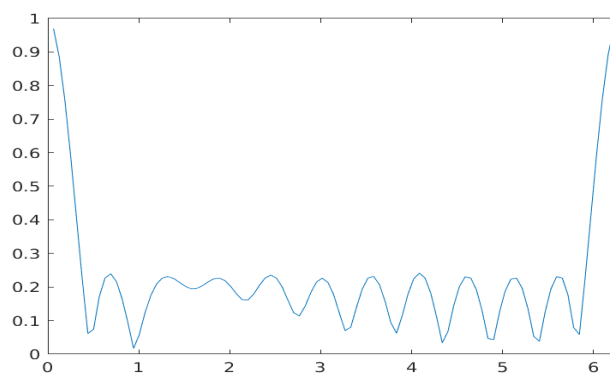```
cvx_begin
    variable z(n) complex;
    variable t
    minimize(t);
    subject to
    abs(A([2 4 96 98],:)*z) <=1 ;
    A(100,:) *z == 1;
    t >= abs(A(6:2:94,:)* z)
cvx_end
z_opt_11 = z;
figure;
plot((1:100)*2*pi/100,abs(A*z_opt_11));
xlim([0 2*pi]);
```

**Optimal Value of t\*:** 0.226499

**Optimal solution:**
-10383.1138071094 - 163.269399834281i
-725.424137435957 + 240.394953526977i
-6506.22702812807 + 1644.07860056596i
3257.67714970138 - 188.535006180435i
-51.9940239919311 + 11.9848672681501i
1706.80367234893 + 766.380178014377i
5573.66155023329 - 1177.89062436128i
53953.7389706186 - 11157.1493238447i
-27243.3011389153 + 5672.66634189655i
4157.18150548597 - 670.638422496560i
-22722.2399195359 + 4857.86752120584i
-3521.07359000768 + 854.857448972947i

**Gain plot 1.1:**



### 1.2)

**CVX Script:**
```
cvx_begin
    variable z(n) complex;
    variable t
    minimize(t);
    subject to
```

```
        abs(A([2 4 6 8 96 98],:)*z) <=1 ;
        A(100,:) *z == 1;
        t >= abs(A(10:94,:)* z)
cvx_end
z_opt_12 = z;
figure;
plot((1:100)*2*pi/100,abs(A*z_opt_12));
xlim([0 2*pi]);
ylim([0 1])
```

**Optimal Value of t\*:** 0.181025

Optimal solution:

-4920.89432907529 - 77.2972970713984i

-410.843176091743 + 246.057363109682i

-3550.02623135432 + 1746.14703972812i

1607.97643140121 - 139.500338789893i

-28.8985009755636 + 11.4323072130659i

609.462017938646 + 713.156440107398i

2902.68714744991 - 1333.83422525878i

28860.5230269783 - 11479.1939711663i

-14518.8852939569 + 5936.38053660442i

2165.79018467415 - 786.478219695416i

-12211.3898325688 + 4955.76446892783i

-1888.72466843904 + 911.532306086210i

**Gain plot 1.2:**
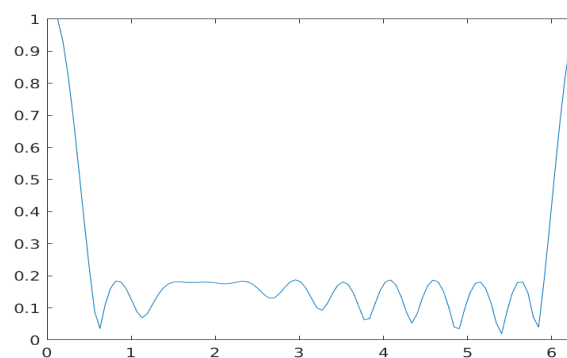


## 1.3)

**CVX Script:**

```
cvx_begin
        variable z(n) complex;
        variable t
        minimize(t);
        subject to
        abs(A([2 4 6 8 92 94 96 98],:)*z) <=1 ;
```

```
        A(100,:) *z == 1;
        t >= abs(A(10:2:90,:)* z)
cvx_end
z_opt_13 = z;
figure;
plot((1:100)*2*pi/100,abs(A*z_opt_13));
xlim([0 2*pi]);
ylim([0 1]);
```
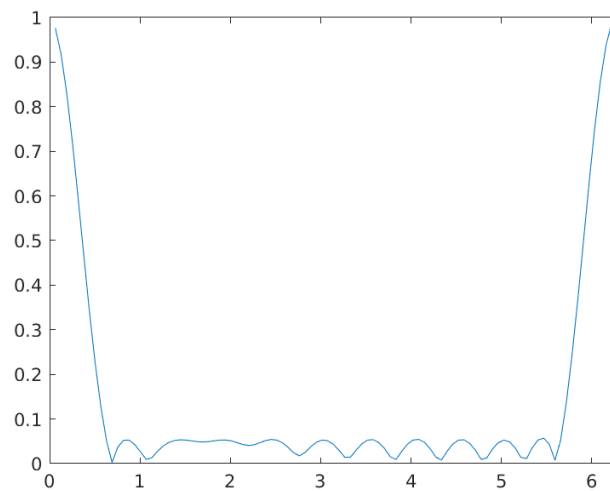
Optimal solution:
-3578.05496983251 - 1053.67543420351i
-255.309295012521 + 56.0219314810965i
-2313.38009928352 + 192.731399685270i
1081.26646201110 + 113.140610109638i
-18.3255308886461 + 2.18163118029564i
594.545534746651 + 602.516851408614i
1961.62781242553 + 20.1451330921648i
18840.5231872529 - 826.539571636327i
-9533.10744668340 + 340.323990917497i
1500.53851739488 + 131.051384497393i
-7922.95959199162 + 466.415455264323i
-1232.83951443955 + 85.2267097723178i

Optimal Value of t*: 0.0527269

Gain plot 1.3:

Problem 2:

2.1)
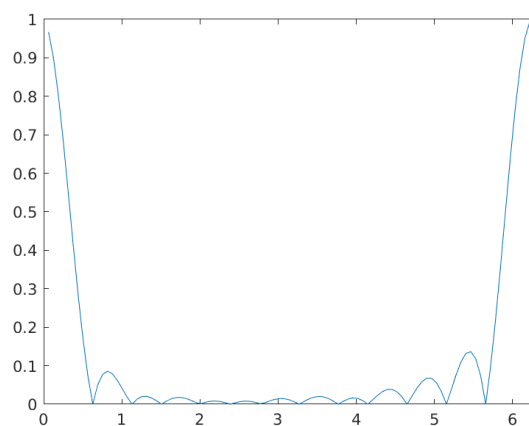
CVX Script:

```
cvx_begin
    variable z(n) complex;
    variable t
    minimize (sum(abs(A([6:2:94],:)*z)));
    subject to
    abs(A([2 4 96 98],:)*z) <= 1 ;
    A(100,:) *z == 1;
cvx_end
z_opt_21 = z;
figure;
plot((1:100)*2*pi/100,abs(A*z));
xlim([0 2*pi]);
ylim([0 1])
```

Optimal solution:
-3120.31861454211 - 2274.48024911636i
-213.118542135766 - 3.09511464493192i
-1958.41458958266 - 432.894792822892i
928.250073210594 + 388.609468097983i
-15.6252878361027 - 1.49369386596794i
548.734587056436 + 924.084956074042i
1659.84876174502 + 655.784226760810i
15983.5802995963 + 4132.87590000067i
-8085.76255481478 - 2262.56676723803i
1289.31061755164 + 622.563997685979i
-6713.16097193691 - 1568.48585188229i
-1039.00937606114 - 262.018692597044i

Optimal Value of t*: 2.3051

Gain plot 2.1:
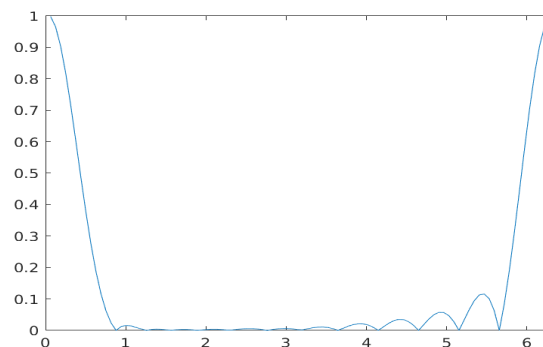
2.2)

CVX Script:

```
cvx_begin
    variable z(n) complex;
    variable t
    minimize (sum(abs(A([10:2:94],:)*z)));
    subject to
    abs(A([2 4 6 8 96 98],:)*z) <= 1 ;
    A(100,:) *z == 1;
cvx_end
z_opt_22 = z;
figure;
plot((1:100)*2*pi/100,abs(A*z));
xlim([0 2*pi]);
ylim([0 1])
```

```
Optimal solution:
-1999.43436936082 - 1917.91878264000i
-145.269629385147 + 1.75635872897582i
-1325.91142602019 - 315.610357228051i
580.194573317775 + 350.241576293546i
-10.5726292929671 - 1.40818010032255i
337.240332250753 + 778.737777575668i
1090.69477261859 + 490.598300445468i
10672.0574272233 + 3313.55366673598i
-5387.79331535287 - 1784.23188235106i
871.837645244642 + 482.085568096843i
-4487.50380018207 - 1261.18882718771i
-690.869054704997 - 194.513730882957i
```

Optimal Value of t*: 1.53236

Gain plot 2.2:

2.3)

CVX Script:

```
cvx_begin
    variable z(n) complex;
    variable t
    minimize (sum(abs(A([10:2:90],:)*z)));
    subject to
    abs(A([2 4 6 8 92 94 96 98],:)*z) <= 1;
    A(100,:) *z == 1;
cvx_end
z_opt_23 = z;
figure;
plot((1:100)*2*pi/100,abs(A*z));
xlim([0 2*pi])
ylim([0 1])
```
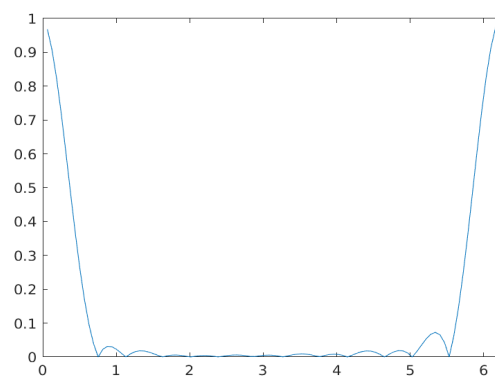
Optimal solution:
-1725.29113749547 - 1646.41350876918i
-127.036272183958 - 8.08330156941777i
-1158.66524866847 - 358.781860841494i
516.247669259785 + 277.059042939563i
-9.37551394300039 - 1.35565218891470i
277.811882006819 + 656.198277972116i
961.479563287664 + 514.960097833882i
9291.77146938117 + 3263.72766693377i
-4701.86862991761 - 1785.03109652721i
752.652894745556 + 477.012896740692i
-3905.47798405386 - 1250.67285761296i
-605.785144527171 - 213.843691198165i

Optimal Value of t*: 0.66002

Gain plot 2.3:
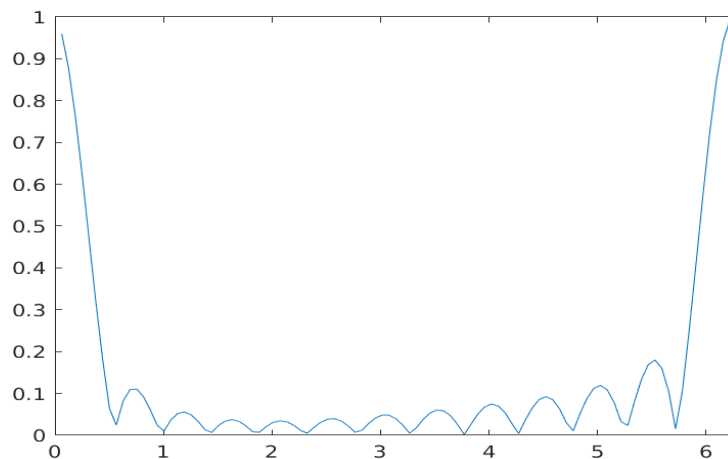
Problem 3:

3.1)

CVX Script:

```
cvx_begin
    variable z(n) complex;
    minimize (sum(pow_abs(A(6:2:94,:)*z,2)));
    subject to
    A(100,:) * z == 1;
    abs(A([2 4 96 98],:)*z) <= 1;
cvx_end
z_opt_31 = z;
figure;
plot((1:100)*2*pi/100,abs(A*z_opt_31));
xlim([0 2*pi])
ylim([0 1])
```

Optimal solution:
-6446.10484449639 - 2441.13389029210i
-409.689549798416 + 22.2533338145743i
-3785.22589949203 - 289.696597868697i
1934.95985597011 + 389.884217814133i
-29.9125288862334 - 0.238256600339393i
1204.37042077291 + 1068.64795687690i
3288.81202307662 + 576.675732651178i
31511.1547345731 + 3212.07289675439i
-15939.4139317693 - 1808.66938932492i
2510.94438094859 + 596.898287751019i
-13227.6128494232 - 1150.38139263762i
-2044.79250917177 - 188.789940097585i

Optimal Value of t*: 0.449627

Gain plot 3.1:

3.2)

CVX Script:
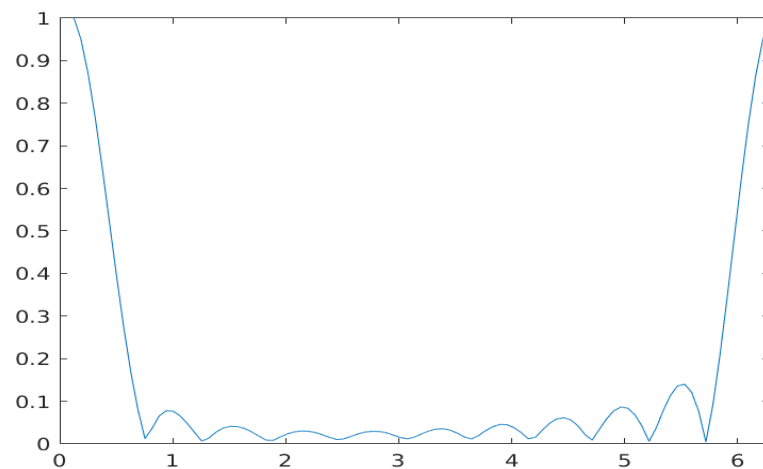
```
cvx_begin
     variable z(n) complex;
     minimize (sum(pow_abs(A(10:2:94,:)*z,2)));
     subject to
     A(100,:) * z == 1;
     abs(A([2 4 6 8 96 98],:)*z) <= 1;
cvx_end
z_opt_32 = z;
figure;
plot((1:100)*2*pi/100,abs(A*z_opt_32));
xlim([0 2*pi])
ylim([0 1])

Optimal solution:
-1660.66231395889 - 1916.95675119846i
-131.628264345310 + 47.6596388531831i
-1185.63797924350 + 20.9134969457062i
475.060578024577 + 332.723392084368i
-9.50152992201901 + 0.600612225899819i
256.139590861226 + 900.164958917347i
942.744924143142 + 213.930751925586i
9406.37602402137 + 1164.95323520564i
-4736.57974982457 - 651.439607785489i
771.406207939966 + 318.490764208488i
-3963.08190735587 - 341.547918221021i
-607.105301150217 - 16.3567534149974i
```

Optimal Value of t*: 0.248314

Gain plot 3.2:

3.3)

CVX Script:

```
cvx_begin
    variable z(n) complex;
    minimize (sum(pow_abs(A(10:2:90,:)*z,2)));
    subject to
    A(100,:) * z == 1;
    abs(A([2 4 6 8 92 94 96 98],:)*z) <= 1;
cvx_end
z_opt_33 = z;
figure;
plot((1:100)*2*pi/100,abs(A*z_opt_33));
xlim([0 2*pi])
ylim([0 1])
```

Optimal solution:
-1723.73476786934 - 1508.07778328504i
-129.681366356000 + 18.1788182088613i
-1176.75818797139 - 157.029723141250i
515.362064838584 + 217.030423929652i
-9.52696967715182 + 0.159968199280783i
271.074264286909 + 682.807143143298i
968.129478834493 + 353.764189741936i
9419.74622884522 + 1754.68424237428i
-4761.49446303256 - 1018.05661625390i
761.449899111883 + 373.490374318154i
-3962.27150748495 - 604.899089472736i
-613.296350956921 - 105.648867642683i

Optimal Value of t*: 0.0383433

Gain plot 3: