ECE104.1 PROBLEM SET 2

A Laboratory Report Presented to
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Problem Set 2

ECE 104.1 - Signals, Spectra & Signal Processing Laboratory

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ECE104.1 PROBLEM SET 2

No. 1

Let $X(e^{j\omega})$ be the DTFT of a finite-length sequence

$$x(n) = \begin{cases} n+1, & 0 \le n \le 49; \\ 100-n, & 50 \le n \le 99; \\ 0, & \text{otherwise.} \end{cases}$$

1. Let

$$y_1(n) = \overset{10\text{-point}}{\text{IDFS}} \left[X(e^{j0}), X(e^{j2\pi/10}), X(e^{j4\pi/10}), \ldots, X(e^{j18\pi/10})\right]$$

   Determine $y_1(n)$ using the frequency sampling theorem. Verify your answer using MATLAB.

2. Let

$$y_2(n) = \overset{200\text{-point}}{\text{IDFS}} \left[X(e^{j0}), X(e^{j2\pi/200}), X(e^{j4\pi/200}), \ldots, X(e^{j398\pi/200})\right]$$

   Determine $y_2(n)$ using the frequency sampling theorem. Verify your answer using MATLAB.

No. 2

Consider the following finite-length sequence.

$$x(n) = \begin{cases} \text{sinc}^2\{(n-50)/2\}, & 0 \le n \le 100; \\ 0, & \text{else.} \end{cases}$$

1. Determine the DFT $X(k)$ of $x(n)$. Plot (using the `stem` function) its magnitude and phase.
2. Plot the magnitude and phase of the DTFT $X(e^{j\omega})$ of $x(n)$ using MATLAB.
3. Verify that the above DFT is the sampled version of $X(e^{j\omega})$. It might be helpful to combine the above two plots in one graph using the `hold` function.
4. Is it possible to reconstruct the DTFT $X(e^{j\omega})$ from the DFT $X(k)$? If possible, give the necessary interpolation formula for reconstruction. If not possible, state why this reconstruction cannot be done.

No. 3

A filter is described by the following difference equation:

$14y(n) + 10y(n-1) + 2y(n-2) - 4y(n-3) - y(n-4) = x(n) - 3x(n-1) + 11x(n-2) - 27x(n-3) + 18x(n-4)$

Determine its cascaded form structure.

No.1

$y_1(n) = \sum_{r=-\infty}^{\infty} x(n-10r) = \{1 + 11 + \cdots + 41 + 50 + 40 + \cdots + 10, 2 + 12 + \cdots + 42 + 49 + \cdots + 9, \cdots\}_{periodic}$
$= \{255, 255, \ldots, 255\}_{periodic}$

MATLAB Command Window

```
>> % JEPH MARI M. DALIGDIG BS-ECE
>> % ECE104.1 LAB 2

>> n = 0:99 n =

  Columns 1 through 23

    0    1    2    3    4    5    6    7    8    9   10   11   12   13   ↙

14   15   16   17   18   19   20   21   22

  Columns 24 through 46

   23   24   25   26   27   28   29   30   31   32   33   34   35   36   ↙

37   38   39   40   41   42   43   44   45

  Columns 47 through 69

   46   47   48   49   50   51   52   53   54   55   56   57   58   59   ↙

60   61   62   63   64   65   66   67   68

  Columns 70 through 92

   69   70   71   72   73   74   75   76   77   78   79   80   81   82   ↙

83   84   85   86   87   88   89   90   91

  Columns 93 through 100    92   93   94
95   96   97   98   99


>> x = [n(1:50)+1,100-
n(51:100)]

x =

  Columns 1 through 23

    1    2    3    4    5    6    7    8    9   10   11   12   13   14   ↙
```

```
15    16    17    18    19    20    21    22    23

  Columns 24 through 46

    24    25    26    27    28    29    30    31    32    33    34    35    36    37 ↙

38    39    40    41    42    43    44    45    46

  Columns 47 through 69

    47    48    49    50    50    49    48    47    46    45    44    43    42    41 ↙

40    39    38    37    36    35    34    33    32

  Columns 70 through 92

    31    30    29    28    27    26    25    24    23    22    21    20    19    18 ↙

17    16    15    14    13    12    11    10     9

  Columns 93 through 100      8     7     6     5
4     3     2     1

>> N1 = 10

N1 =

  10
>>
k1 =
0:N
1-1

k1 =

     0     1     2     3     4     5     6     7     8     9

>> w1 =
2*pi*k1/N1

w1 =

         0    0.6283    1.2566    1.8850    2.5133    3.1416    3.7699    4.3982 ↙

5.0265    5.6549

>> Y1 = DTFT(x,n,w1)

Y1 =

   1.0e+03 *

  Columns 1 through 7

   2.5500 + 0.0000i   0.0000 + 0.0000i   0.0000 + 0.0000i   0.0000 - 0.0000i  -0.0000 - ↙
```

```
0.0000i   0.0000 + 0.0000i   0.0000 + 0.0000i

  Columns 8 through 10

   0.0000 - 0.0000i  -0.0000 + 0.0000i   0.0000 + 0.0000i

>> y1 =
real(idfs(Y1,N1))

y1 =

  255.0000  255.0000  255.0000  255.0000  255.0000  255.0000  255.0000  255.0000

255.0000  255.0000

>> Hf_1 = figure

Hf_1 =

  Figure (1) with properties:

      Number: 1
        Name: ''
       Color: [0.9400 0.9400 0.9400]
    Position: [403 246 560 420]
       Units: 'pixels'

  Show all properties

>> Hs = stem(n,x)

Hs =

  Stem with properties:

             Color: [0 0.4470 0.7410]
         LineStyle: '-'
         LineWidth: 0.5000
            Marker: 'o'
        MarkerSize: 6
   MarkerFaceColor: 'none'
         BaseValue: 0
```

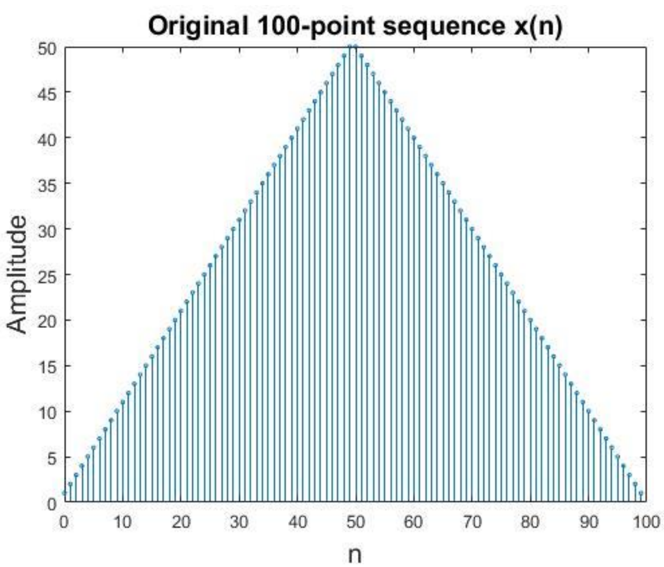
XData: [1×100 double]

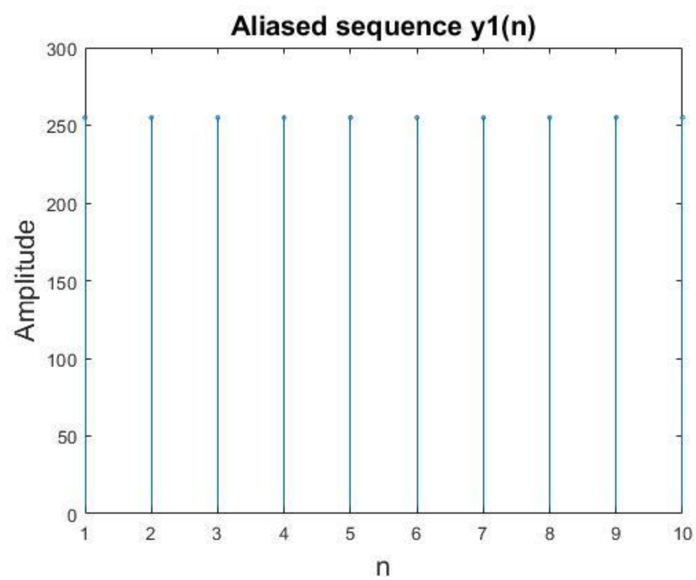
YData: [1×100 double]

Show all properties

```
>> set(Hf_1,'NumberTitle','off','Name','Problem 3')
>> set(Hs,'markersize',2)
>> xlabel('n','FontSize',15)
>> ylabel('Amplitude','FontSize',15)
>> title('Original 100-point sequence x(n)','FontSize',15)
```

Stem plot of y1(n)





2.

The equation is a 200-point IDFS of 200 samples of X (e^ jω) on the unit circle. Therefore

$$y_2(n) = \left\{ \begin{array}{ll} x(n), & 0 \le n \le 49; \\ 0, & 50 \le n \le 100. \end{array} \right\}_{\text{periodic}}$$

We could conclude that the stem plot of y1(n) is still the same however it's not in terms of y2. The MATLAB verification for this is shown below.

MATLAB Command Window

```
>> % JEPH MARI M. DALIGDIG BS-ECE
>> % ECE104.1 LAB 2

 >> n = 0:99 n =

  Columns 1 through 23

     0     1     2     3     4     5     6     7     8     9    10    11    12    13    ↙
14    15    16    17    18    19    20    21    22

  Columns 24 through 46

    23    24    25    26    27    28    29    30    31    32    33    34    35    36    ↙
37    38    39    40    41    42    43    44    45

  Columns 47 through 69

    46    47    48    49    50    51    52    53    54    55    56    57    58    59    ↙
60    61    62    63    64    65    66    67    68

  Columns 70 through 92

    69    70    71    72    73    74    75    76    77    78    79    80    81    82    ↙
83    84    85    86    87    88    89    90    91

  Columns 93 through 100     92    93    94    95
96    97    98    99

>> x = [n(1:50)+1,100-n(51:100)] x
=

  Columns 1 through 23

     1     2     3     4     5     6     7     8     9    10    11    12    13    14    ↙
```

```
15    16    17    18    19    20    21    22    23

  Columns 24 through 46

    24    25    26    27    28    29    30    31    32    33    34    35    36    37
38    39    40    41    42    43    44    45    46

  Columns 47 through 69

    47    48    49    50    50    49    48    47    46    45    44    43    42    41
40    39    38    37    36    35    34    33    32

  Columns 70 through 92

    31    30    29    28    27    26    25    24    23    22    21    20    19    18
17    16    15    14    13    12    11    10     9

  Columns 93 through 100      8     7     6     5     4
3     2     1

>> N2 = 200

N2 =

   200
>> k2 =
0:N2-1

k2 =

  Columns 1 through 23

     0     1     2     3     4     5     6     7     8     9    10    11    12    13
14    15    16    17    18    19    20    21    22

  Columns 24 through 46

    23    24    25    26    27    28    29    30    31    32    33    34    35    36
37    38    39    40    41    42    43    44    45

  Columns 47 through 69

    46    47    48    49    50    51    52    53    54    55    56    57    58    59
60    61    62    63    64    65    66    67    68

  Columns 70 through 92

    69    70    71    72    73    74    75    76    77    78    79    80    81    82
83    84    85    86    87    88    89    90    91
```

Columns 93 through 115

92 93 94 95 96 97 98 99 100 101 102 103 104 105 ↙

106 107 108 109 110 111 112 113 114

Columns 116 through 138

115 116 117 118 119 120 121 122 123 124 125 126 127 128 ↙

129 130 131 132 133 134 135 136 137

Columns 139 through 161

138 139 140 141 142 143 144 145 146 147 148 149 150 151 ↙

152 153 154 155 156 157 158 159 160

Columns 162 through 184

161 162 163 164 165 166 167 168 169 170 171 172 173 174 ↙

175 176 177 178 179 180 181 182 183

Columns 185 through 200

184 185 186 187 188 189 190 191 192 193 194 195 196 197 ↙

198 199

```
>> w2 =
2*pi*k2/N2 w2
=
```

Columns 1 through 13

0 0.0314 0.0628 0.0942 0.1257 0.1571 0.1885 0.2199 ↙

0.2513 0.2827 0.3142 0.3456 0.3770

Columns 14 through 26

0.4084 0.4398 0.4712 0.5027 0.5341 0.5655 0.5969 0.6283 ↙

0.6597 0.6912 0.7226 0.7540 0.7854

Columns 27 through 39

0.8168 0.8482 0.8796 0.9111 0.9425 0.9739 1.0053 1.0367 ↙

1.0681 1.0996 1.1310 1.1624 1.1938

Columns 40 through 52

1.2252 1.2566 1.2881 1.3195 1.3509 1.3823 1.4137 1.4451 ↙

1.4765 1.5080 1.5394 1.5708 1.6022

Columns 53 through 65

1.6336 1.6650 1.6965 1.7279 1.7593 1.7907 1.8221 1.8535 ↙

1.8850 1.9164 1.9478 1.9792 2.0106

Columns 66 through 78

2.0420 2.0735 2.1049 2.1363 2.1677 2.1991 2.2305 2.2619 ↙

2.2934 2.3248 2.3562 2.3876 2.4190

Columns 79 through 91

2.4504 2.4819 2.5133 2.5447 2.5761 2.6075 2.6389 2.6704 ↙

2.7018 2.7332 2.7646 2.7960 2.8274

Columns 92 through 104

2.8588 2.8903 2.9217 2.9531 2.9845 3.0159 3.0473 3.0788 ↙

3.1102 3.1416 3.1730 3.2044 3.2358

Columns 105 through 117

3.2673 3.2987 3.3301 3.3615 3.3929 3.4243 3.4558 3.4872 ↙

3.5186 3.5500 3.5814 3.6128 3.6442

Columns 118 through 130

3.6757 3.7071 3.7385 3.7699 3.8013 3.8327 3.8642 3.8956 ↙

3.9270 3.9584 3.9898 4.0212 4.0527

Columns 131 through 143

4.0841 4.1155 4.1469 4.1783 4.2097 4.2412 4.2726 4.3040 ↙

4.3354 4.3668 4.3982 4.4296 4.4611

Columns 144 through 156

4.4925 4.5239 4.5553 4.5867 4.6181 4.6496 4.6810 4.7124 ↙

4.7438 4.7752 4.8066 4.8381 4.8695

Columns 157 through 169

4.9009 4.9323 4.9637 4.9951 5.0265 5.0580 5.0894 5.1208 ↙

5.1522 5.1836 5.2150 5.2465 5.2779

Columns 170 through 182

```
   5.3093    5.3407    5.3721    5.4035    5.4350    5.4664    5.4978    5.5292    ↙
5.5606    5.5920    5.6235    5.6549    5.6863
  Columns 183 through 195
   5.7177    5.7491    5.7805    5.8119    5.8434    5.8748    5.9062    5.9376    ↙
5.9690    6.0004    6.0319    6.0633    6.0947
  Columns 196 through 200
   6.1261    6.1575    6.1889    6.2204    6.2518
>> Y2 = DTFT(x,n,w2)
Y2 =
   1.0e+03 *
  Columns 1 through 7
   2.5500 + 0.0000i   0.0323 - 2.0579i  -1.0125 - 0.0318i  -0.0101 + 0.2142i   0.0000 -    ↙
0.0000i   0.0069 - 0.0871i  -0.1119 - 0.0106i
  Columns 8 through 14
  -0.0040 + 0.0365i  -0.0000 - 0.0000i   0.0040 - 0.0282i  -0.0399 - 0.0063i  -0.0024 +    ↙
0.0136i  -0.0000 + 0.0000i   0.0029 - 0.0141i
  Columns 15 through 21
  -0.0200 - 0.0045i  -0.0016 + 0.0066i   0.0000 + 0.0000i   0.0023 - 0.0085i  -0.0118 -    ↙
0.0034i  -0.0011 + 0.0037i   0.0000 + 0.0000i
  Columns 22 through 28
   0.0020 - 0.0057i  -0.0077 - 0.0028i  -0.0008 + 0.0022i  -0.0000 - 0.0000i   0.0017 -    ↙
0.0041i  -0.0053 - 0.0023i  -0.0006 + 0.0013i
  Columns 29 through 35
   0.0000 + 0.0000i   0.0015 - 0.0031i  -0.0039 - 0.0020i  -0.0004 + 0.0008i   0.0000 -    ↙
0.0000i   0.0014 - 0.0024i  -0.0029 - 0.0017i
  Columns 36 through 42
  -0.0003 + 0.0005i  -0.0000 - 0.0000i   0.0013 - 0.0019i  -0.0022 - 0.0015i  -0.0002 +    ↙
0.0003i   0.0000 + 0.0000i   0.0012 - 0.0016i
  Columns 43 through 49
```

-0.0017 - 0.0013i -0.0001 + 0.0002i -0.0000 - 0.0000i   0.0011 - 0.0013i -0.0013 - ↙
0.0011i -0.0000 + 0.0001i -0.0000 + 0.0000i

Columns 50 through 56

0.0010 - 0.0010i -0.0010 - 0.0010i   0.0000 - 0.0000i   0.0000 - 0.0000i   0.0010 - ↙
0.0009i -0.0008 - 0.0009i   0.0001 - 0.0001i

Columns 57 through 63

-0.0000 + 0.0000i   0.0009 - 0.0007i -0.0006 - 0.0008i   0.0001 - 0.0001i -0.0000 + ↙
0.0000i   0.0009 - 0.0006i -0.0005 - 0.0007i

Columns 64 through 70

0.0002 - 0.0001i   0.0000 - 0.0000i   0.0008 - 0.0005i -0.0003 - 0.0006i   0.0002 - ↙
0.0001i   0.0000 + 0.0000i   0.0008 - 0.0004i

Columns 71 through 77

-0.0003 - 0.0005i   0.0003 - 0.0001i -0.0000 + 0.0000i   0.0007 - 0.0003i -0.0002 - ↙
0.0004i   0.0003 - 0.0001i   0.0000 - 0.0000i

Columns 78 through 84

0.0007 - 0.0003i -0.0001 - 0.0004i   0.0003 - 0.0001i -0.0000 - 0.0000i   0.0007 - ↙
0.0002i -0.0001 - 0.0003i   0.0004 - 0.0001i

Columns 85 through 91

0.0000 + 0.0000i   0.0006 - 0.0001i -0.0000 - 0.0002i   0.0004 - 0.0001i   0.0000 - ↙
0.0000i   0.0006 - 0.0001i -0.0000 - 0.0002i

Columns 92 through 98

0.0004 - 0.0001i   0.0000 - 0.0000i   0.0006 - 0.0001i -0.0000 - 0.0001i   0.0005 - ↙
0.0000i   0.0000 + 0.0000i   0.0005 - 0.0000i

Columns 99 through 105

-0.0000 - 0.0000i   0.0005 - 0.0000i   0.0000 + 0.0000i   0.0005 + 0.0000i -0.0000 + ↙
0.0000i   0.0005 + 0.0000i   0.0000 + 0.0000i

Columns 106 through 112

0.0005 + 0.0000i -0.0000 + 0.0001i   0.0006 + 0.0001i   0.0000 - 0.0000i   0.0004 + ↙
0.0001i -0.0000 + 0.0002i   0.0006 + 0.0001i

Columns 113 through 119

-0.0000 + 0.0000i   0.0004 + 0.0001i -0.0000 + 0.0002i   0.0006 + 0.0001i -0.0000 + ↙

0.0000i   0.0004 + 0.0001i -0.0001 + 0.0003i

Columns 120 through 126

0.0007 + 0.0002i -0.0000 + 0.0000i   0.0003 + 0.0001i -0.0001 + 0.0004i   0.0007 + ↙

0.0003i -0.0000 - 0.0000i   0.0003 + 0.0001i

Columns 127 through 133

-0.0002 + 0.0004i   0.0007 + 0.0003i -0.0000 - 0.0000i   0.0003 + 0.0001i -0.0003 + ↙

0.0005i   0.0008 + 0.0004i -0.0000 + 0.0000i

Columns 134 through 140

0.0002 + 0.0001i -0.0003 + 0.0006i   0.0008 + 0.0005i -0.0000 + 0.0000i   0.0002 + ↙

0.0001i -0.0005 + 0.0007i   0.0009 + 0.0006i

Columns 141 through 147

0.0000 - 0.0000i   0.0001 + 0.0001i -0.0006 + 0.0008i   0.0009 + 0.0007i -0.0000 + ↙

0.0000i   0.0001 + 0.0001i -0.0008 + 0.0009i

Columns 148 through 154

0.0010 + 0.0009i   0.0000 + 0.0000i   0.0000 + 0.0000i -0.0010 + 0.0010i   0.0010 + ↙

0.0010i   0.0000 - 0.0000i -0.0000 - 0.0001i

Columns 155 through 161

-0.0013 + 0.0011i   0.0011 + 0.0013i   0.0000 - 0.0000i -0.0001 - 0.0002i -0.0017 + ↙

0.0013i   0.0012 + 0.0016i -0.0000 + 0.0000i

Columns 162 through 168

-0.0002 - 0.0003i -0.0022 + 0.0015i   0.0013 + 0.0019i   0.0000 - 0.0000i -0.0003 - ↙

0.0005i -0.0029 + 0.0017i   0.0014 + 0.0024i

Columns 169 through 175

0.0000 + 0.0000i -0.0004 - 0.0008i -0.0039 + 0.0020i   0.0015 + 0.0031i -0.0000 + ↙

0.0000i -0.0006 - 0.0013i -0.0053 + 0.0023i

Columns 176 through 182

0.0017 + 0.0041i -0.0000 + 0.0000i -0.0008 - 0.0022i -0.0077 + 0.0028i   0.0020 + ↙

```
0.0057i   0.0000 + 0.0000i  -0.0011 - 0.0037i

  Columns 183 through 189

  -0.0118 + 0.0034i   0.0023 + 0.0085i   0.0000 + 0.0000i  -0.0016 - 0.0066i  -0.0200 +
0.0045i   0.0029 + 0.0141i   0.0000 + 0.0000i

  Columns 190 through 196

  -0.0024 - 0.0136i  -0.0399 + 0.0063i   0.0040 + 0.0282i  -0.0000 + 0.0000i  -0.0040 -
0.0365i  -0.1119 + 0.0106i   0.0069 + 0.0871i

  Columns 197 through 200

   0.0000 - 0.0000i  -0.0101 - 0.2142i  -1.0125 + 0.0318i   0.0323 + 2.0579i

>> y2 = real(idfs(Y2,N2))
y2 =

  Columns 1 through 13

    1.0000    2.0000    3.0000    4.0000    5.0000    6.0000    7.0000    8.0000
9.0000   10.0000   11.0000   12.0000   13.0000

  Columns 14 through 26

   14.0000   15.0000   16.0000   17.0000   18.0000   19.0000   20.0000   21.0000
22.0000   23.0000   24.0000   25.0000   26.0000

  Columns 27 through 39

   27.0000   28.0000   29.0000   30.0000   31.0000   32.0000   33.0000   34.0000
35.0000   36.0000   37.0000   38.0000   39.0000

  Columns 40 through 52

   40.0000   41.0000   42.0000   43.0000   44.0000   45.0000   46.0000   47.0000
48.0000   49.0000   50.0000   50.0000   49.0000

  Columns 53 through 65

   48.0000   47.0000   46.0000   45.0000   44.0000   43.0000   42.0000   41.0000
40.0000   39.0000   38.0000   37.0000   36.0000

  Columns 66 through 78

   35.0000   34.0000   33.0000   32.0000   31.0000   30.0000   29.0000   28.0000
27.0000   26.0000   25.0000   24.0000   23.0000
```

Columns 79 through 91

22.0000 21.0000 20.0000 19.0000 18.0000 17.0000 16.0000 15.0000 ↙
14.0000 13.0000 12.0000 11.0000 10.0000

Columns 92 through 104

9.0000 8.0000 7.0000 6.0000 5.0000 4.0000 3.0000 2.0000 ↙
1.0000 0.0000 0.0000 0.0000 0.0000

Columns 105 through 117

0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 ↙
0.0000 0.0000 0.0000 0.0000 0.0000

Columns 118 through 130

0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 ↙
0.0000 0.0000 0.0000 0.0000 0.0000

Columns 131 through 143

0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 ↙
0.0000 0.0000 0.0000 0.0000 0.0000

Columns 144 through 156

0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 ↙
0.0000 0.0000 0.0000 0.0000 0.0000

Columns 157 through 169

0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 ↙
0.0000 0.0000 0.0000 0.0000 0.0000

Columns 170 through 182

0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 ↙
0.0000 0.0000 0.0000 0.0000 0.0000

Columns 183 through 195

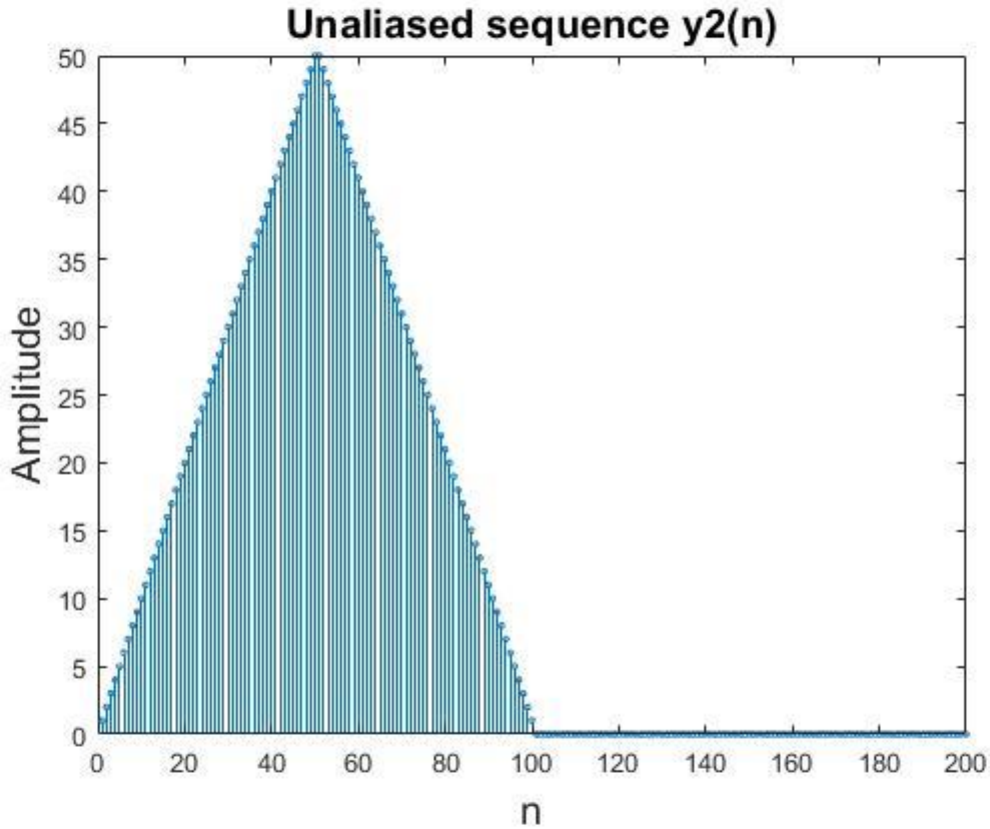
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 ↙
0.0000 0.0000 0.0000 0.0000 0.0000

Columns 196 through 200

0.0000 0.0000 0.0000 0.0000 0.0000

```
>> Hf_1 = figure

Hf_1 =

  Figure (1) with properties:

      Number: 1
        Name: ''
       Color: [0.9400 0.9400 0.9400]
    Position: [403 246 560 420]
       Units: 'pixels'

  Show all properties

>> Hs = stem(y2)

Hs =

  Stem with properties:

              Color: [0 0.4470 0.7410]
          LineStyle: '-'
          LineWidth: 0.5000
             Marker: 'o'
         MarkerSize: 6
    MarkerFaceColor: 'none'
          BaseValue: 0
              XData: [1×200 double]
              YData: [1×200 double]

  Show all properties

>> set(Hf_1,'NumberTitle','off','Name','Problem 2')
>> set(Hs,'markersize',2)
>> xlabel('n','FontSize',15)
>> ylabel('Amplitude','FontSize',15)
>> title('Unaliased sequence y2(n)','FontSize',15)
```

Unaliased sequence of y2(n)



No.2

$$x(n) = \begin{cases} \text{sinc}^2\{(n-50)/2\}, & 0 \le n \le 100; \\ 0, & \text{else.} \end{cases}$$

Using MATLAB the codes are listed below as well as the magnitude and phase plot.

MATLAB Command Window

```
>> % JEPH MARI M. DALIGDIG BS-ECE
>> % ECE104.1 LAB 2

>> n = 0:100 n =

  Columns 1 through 23

    0    1    2    3    4    5    6    7    8    9   10   11   12   13   ↙
14   15   16   17   18   19   20   21   22

  Columns 24 through 46

   23   24   25   26   27   28   29   30   31   32   33   34   35   36   ↙
37   38   39   40   41   42   43   44   45

  Columns 47 through 69

   46   47   48   49   50   51   52   53   54   55   56   57   58   59   ↙
60   61   62   63   64   65   66   67   68

  Columns 70 through 92

   69   70   71   72   73   74   75   76   77   78   79   80   81   82   ↙
83   84   85   86   87   88   89   90   91

  Columns 93 through 101

   92   93   94   95   96   97   98   99  100

>> xn = sinc((n-50)/2).^2
xn =

  Columns 1 through 14

   0.0000   0.0002   0.0000   0.0002   0.0000   0.0002   0.0000   0.0002   ↙
0.0000   0.0002   0.0000   0.0003   0.0000   0.0003

  Columns 15 through 28
```

```
    0.0000    0.0003    0.0000    0.0004    0.0000    0.0004    0.0000    0.0005    ↙
0.0000    0.0006    0.0000    0.0006    0.0000    0.0008

  Columns 29 through 42

    0.0000    0.0009    0.0000    0.0011    0.0000    0.0014    0.0000    0.0018    ↙
0.0000    0.0024    0.0000    0.0033    0.0000    0.0050

  Columns 43 through 56

    0.0000    0.0083    0.0000    0.0162    0.0000    0.0450    0.0000    0.4053    ↙
1.0000    0.4053    0.0000    0.0450    0.0000    0.0162

  Columns 57 through 70

    0.0000    0.0083    0.0000    0.0050    0.0000    0.0033    0.0000    0.0024    ↙
0.0000    0.0018    0.0000    0.0014    0.0000    0.0011

  Columns 71 through 84

    0.0000    0.0009    0.0000    0.0008    0.0000    0.0006    0.0000    0.0006    ↙
0.0000    0.0005    0.0000    0.0004    0.0000    0.0004

  Columns 85 through 98

    0.0000    0.0003    0.0000    0.0003    0.0000    0.0003    0.0000    0.0002    ↙
0.0000    0.0002    0.0000    0.0002    0.0000    0.0002

  Columns 99 through 101

    0.0000    0.0002    0.0000

>> N = length(xn)

N =

   101

>> Xk = dft(xn,N)

Xk =

  Columns 1 through 7

   1.9919 + 0.0000i  -1.9605 - 0.0610i   1.9167 + 0.1194i  -1.8732 - 0.1753i   1.8272 +    ↙
0.2285i  -1.7804 - 0.2791i   1.7317 + 0.3270i

  Columns 8 through 14

  -1.6822 - 0.3722i   1.6312 + 0.4145i  -1.5797 - 0.4541i   1.5269 + 0.4909i  -1.4738 -    ↙
```

0.5249i   1.4197 + 0.5560i -1.3655 - 0.5843i

Columns 15 through 21

1.3105 + 0.6097i -1.2558 - 0.6325i   1.2005 + 0.6522i -1.1456 - 0.6694i   1.0905 + ↙
0.6835i -1.0360 - 0.6952i   0.9815 + 0.7038i

Columns 22 through 28

-0.9279 - 0.7101i   0.8745 + 0.7134i -0.8222 - 0.7144i   0.7703 + 0.7126i -0.7197 - ↙
0.7086i   0.6698 + 0.7018i -0.6214 - 0.6930i

Columns 29 through 35

0.5739 + 0.6815i -0.5280 - 0.6682i   0.4832 + 0.6522i -0.4403 - 0.6346i   0.3986 + ↙
0.6146i -0.3590 - 0.5930i   0.3208 + 0.5691i

Columns 36 through 42

-0.2847 - 0.5440i   0.2502 + 0.5167i -0.2180 - 0.4884i   0.1876 + 0.4579i -0.1595 - ↙
0.4268i   0.1333 + 0.3936i -0.1096 - 0.3602i

Columns 43 through 49

0.0879 + 0.3246i -0.0687 - 0.2893i   0.0516 + 0.2518i -0.0372 - 0.2151i   0.0248 + ↙
0.1759i -0.0151 - 0.1385i   0.0076 + 0.0978i

Columns 50 through 56

-0.0028 - 0.0608i   0.0003 + 0.0173i   0.0003 - 0.0173i -0.0028 + 0.0608i   0.0076 - ↙
0.0978i -0.0151 + 0.1385i   0.0248 - 0.1759i

Columns 57 through 63

-0.0372 + 0.2151i   0.0516 - 0.2518i -0.0687 + 0.2893i   0.0879 - 0.3246i -0.1096 + ↙
0.3602i   0.1333 - 0.3936i -0.1595 + 0.4268i

Columns 64 through 70

0.1876 - 0.4579i -0.2180 + 0.4884i   0.2502 - 0.5167i -0.2847 + 0.5440i   0.3208 - ↙
0.5691i -0.3590 + 0.5930i   0.3986 - 0.6146i

Columns 71 through 77

-0.4403 + 0.6346i   0.4832 - 0.6522i -0.5280 + 0.6682i   0.5739 - 0.6815i -0.6214 + ↙
0.6930i   0.6698 - 0.7018i -0.7197 + 0.7086i

Columns 78 through 84

0.7703 - 0.7126i -0.8222 + 0.7144i   0.8745 - 0.7134i -0.9279 + 0.7101i   0.9815 - ↙

0.7038i -1.0360 + 0.6952i   1.0905 - 0.6835i

Columns 85 through 91

-1.1456 + 0.6694i   1.2005 - 0.6522i -1.2558 + 0.6325i   1.3105 - 0.6097i -1.3655 + ↙

0.5843i   1.4197 - 0.5560i -1.4738 + 0.5249i

Columns 92 through 98

1.5269 - 0.4909i -1.5797 + 0.4541i   1.6312 - 0.4145i -1.6822 + 0.3722i   1.7317 - ↙

0.3270i -1.7804 + 0.2791i   1.8272 - 0.2285i

Columns 99 through 101

-1.8732 + 0.1753i   1.9167 - 0.1194i -1.9605 + 0.0610i

>> k =
0:N-1 k
=

Columns 1 through 23

0 1 2 3 4 5 6 7 8 9 10 11 12 13 ↙

14 15 16 17 18 19 20 21 22

Columns 24 through 46

23 24 25 26 27 28 29 30 31 32 33 34 35 36 ↙

37 38 39 40 41 42 43 44 45

Columns 47 through 69

46 47 48 49 50 51 52 53 54 55 56 57 58 59 ↙

60 61 62 63 64 65 66 67 68

Columns 70 through 92

69 70 71 72 73 74 75 76 77 78 79 80 81 82 ↙

83 84 85 86 87 88 89 90 91

Columns 93 through 101

92 93 94 95 96 97 98 99 100

>> mag_Xk = abs(Xk)
mag_Xk =

Columns 1 through 13

1.9919 1.9614 1.9204 1.8814 1.8414 1.8021 1.7623 1.7229 ↙

1.6831 1.6437 1.6039 1.5645 1.5247

Columns 14 through 26

1.4852 1.4454 1.4060 1.3662 1.3268 1.2870 1.2476 1.2078 ↙

1.1684 1.1286 1.0892 1.0494 1.0100

Columns 27 through 39

0.9702 0.9308 0.8910 0.8516 0.8117 0.7724 0.7325 0.6932 ↙

0.6533 0.6140 0.5741 0.5348 0.4948

Columns 40 through 52

0.4557 0.4156 0.3765 0.3363 0.2974 0.2570 0.2183 0.1777 ↙

0.1393 0.0981 0.0608 0.0173 0.0173

Columns 53 through 65

0.0608 0.0981 0.1393 0.1777 0.2183 0.2570 0.2974 0.3363 ↙

0.3765 0.4156 0.4557 0.4948 0.5348

Columns 66 through 78

0.5741 0.6140 0.6533 0.6932 0.7325 0.7724 0.8117 0.8516 ↙

0.8910 0.9308 0.9702 1.0100 1.0494

Columns 79 through 91

1.0892 1.1286 1.1684 1.2078 1.2476 1.2870 1.3268 1.3662 ↙

1.4060 1.4454 1.4852 1.5247 1.5645

Columns 92 through 101

1.6039 1.6437 1.6831 1.7229 1.7623 1.8021 1.8414 1.8814 1.9204 1.9614 ↙

>> pha_Xk = angle(Xk)*180/pi
pha_Xk =

Columns 1 through 13

0 -178.2178 3.5644 -174.6535 7.1287 -171.0891 10.6931 -167.5248 ↙

14.2574 -163.9604 17.8218 -160.3960 21.3861

Columns 14 through 26

-156.8317 24.9505 -153.2673 28.5149 -149.7030 32.0792 -146.1386 35.6436 ↙

```
-142.5743   39.2079 -139.0099   42.7723 -135.4455

  Columns 27 through 39

   46.3366 -131.8812   49.9010 -128.3168   53.4653 -124.7525   57.0297 -121.1881   ↙
60.5941 -117.6238   64.1584 -114.0594   67.7228

  Columns 40 through 52

 -110.4950   71.2871 -106.9307   74.8515 -103.3663   78.4158  -99.8020   81.9802   ↙
-96.2376   85.5446  -92.6733   89.1089  -89.1089

  Columns 53 through 65

   92.6733  -85.5446   96.2376  -81.9802   99.8020  -78.4158  103.3663  -74.8515   ↙
106.9307  -71.2871  110.4950  -67.7228  114.0594

  Columns 66 through 78

  -64.1584  117.6238  -60.5941  121.1881  -57.0297  124.7525  -53.4653  128.3168   ↙
-49.9010  131.8812  -46.3366  135.4455  -42.7723

  Columns 79 through 91

  139.0099  -39.2079  142.5743  -35.6436  146.1386  -32.0792  149.7030  -28.5149   ↙
153.2673  -24.9505  156.8317  -21.3861  160.3960

  Columns 92 through 101

  -17.8218  163.9604  -14.2574  167.5248  -10.6931  171.0891   -7.1287  174.6535   ↙
-3.5644  178.2178

>> zei = find(mag_Xk < 0.00001)
zei =

  1×0 empty double row vector >>
pha_Xk(zei) = zeros(1,length(zei))
pha_Xk =

  Columns 1 through 13

         0 -178.2178    3.5644 -174.6535    7.1287 -171.0891   10.6931 -167.5248   ↙
14.2574 -163.9604   17.8218 -160.3960   21.3861

  Columns 14 through 26

 -156.8317   24.9505 -153.2673   28.5149 -149.7030   32.0792 -146.1386   35.6436   ↙
-142.5743   39.2079 -139.0099   42.7723 -135.4455
```

Columns 27 through 39

46.3366 -131.8812 49.9010 -128.3168 53.4653 -124.7525 57.0297 -121.1881 ↙

60.5941 -117.6238 64.1584 -114.0594 67.7228

Columns 40 through 52

-110.4950 71.2871 -106.9307 74.8515 -103.3663 78.4158 -99.8020 81.9802 ↙

-96.2376 85.5446 -92.6733 89.1089 -89.1089

Columns 53 through 65

92.6733 -85.5446 96.2376 -81.9802 99.8020 -78.4158 103.3663 -74.8515 ↙

106.9307 -71.2871 110.4950 -67.7228 114.0594

Columns 66 through 78

-64.1584 117.6238 -60.5941 121.1881 -57.0297 124.7525 -53.4653 128.3168 ↙

-49.9010 131.8812 -46.3366 135.4455 -42.7723

Columns 79 through 91

139.0099 -39.2079 142.5743 -35.6436 146.1386 -32.0792 149.7030 -28.5149 ↙

153.2673 -24.9505 156.8317 -21.3861 160.3960

Columns 92 through 101

-17.8218 163.9604 -14.2574 167.5248 -10.6931 171.0891 -7.1287 174.6535 ↙

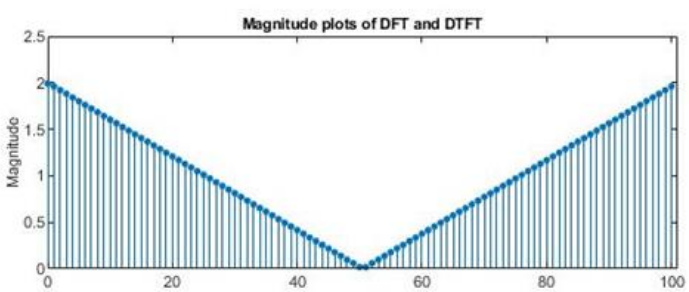
-3.5644 178.2178 ↙

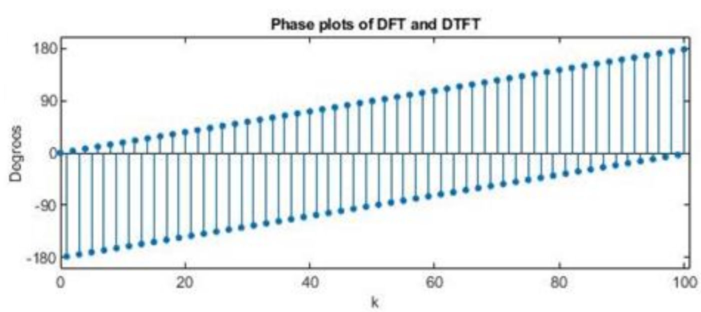
```
>> Hf_1 = figure('Units','normalized','position',[0.1,0.1,0.8,0.8],'color',
[0.9400,0.9400,0.9400],'paperunits','inches','paperposition',[0,0,6,5])

Hf_1 =

  Figure (1) with properties:

      Number: 1
        Name: ''
       Color: [0.9400 0.9400 0.9400]
    Position: [0.1000 0.1000 0.8000 0.8000]
       Units: 'normalized'
```

```
  Show all properties

>> set(Hf_1,'NumberTitle','off','Name','2.1')
>> subplot(2,1,1)

>> H_s1 = stem(k,mag_Xk,'filled')

H_s1 =

  Stem with properties:


              Color: [0 0.4470 0.7410]

          LineStyle: '-'

          LineWidth: 0.5000

             Marker: 'o'

         MarkerSize: 6

    MarkerFaceColor: 'auto'

          BaseValue: 0

              XData: [1×101 double]

              YData: [1×101 double]


  Show all properties

>> set(H_s1,'markersize',3)

>> set(gca,'XTick',[0:20:N],'fontsize',8)

>> axis([0,N,0,2.5])

>> set(gca,'YTick',[0:0.5:2.5],'fontsize',8)

>> ylabel('Magnitude')

>> title('Magnitude plots of DFT and DTFT','fontsize',10)
>> hold on

>> subplot(2,1,2)

>> H_s2 = stem(k,pha_Xk,'filled')

H_s2 =

  Stem with properties:
```

```
            Color: [0 0.4470 0.7410]

          LineStyle: '-'

          LineWidth: 0.5000

             Marker: 'o'

         MarkerSize: 6

    MarkerFaceColor: 'auto'

          BaseValue: 0

              XData: [1×101 double]

              YData: [1×101 double]


  Show all properties

>> set(H_s2,'markersize',3)

>> set(gca,'XTick',[0:20:N],'fontsize',8)

>> axis([0,N,-200,200])

>> set(gca,'YTick',[-180;-90;0;90;180],'fontsize',8)

>> xlabel('k')

>> ylabel('Degrees')

>> title('Phase plots of DFT and DTFT','fontsize',10)
>> hold on
```

Magnitude and phase plot of DFT [x(n)] :



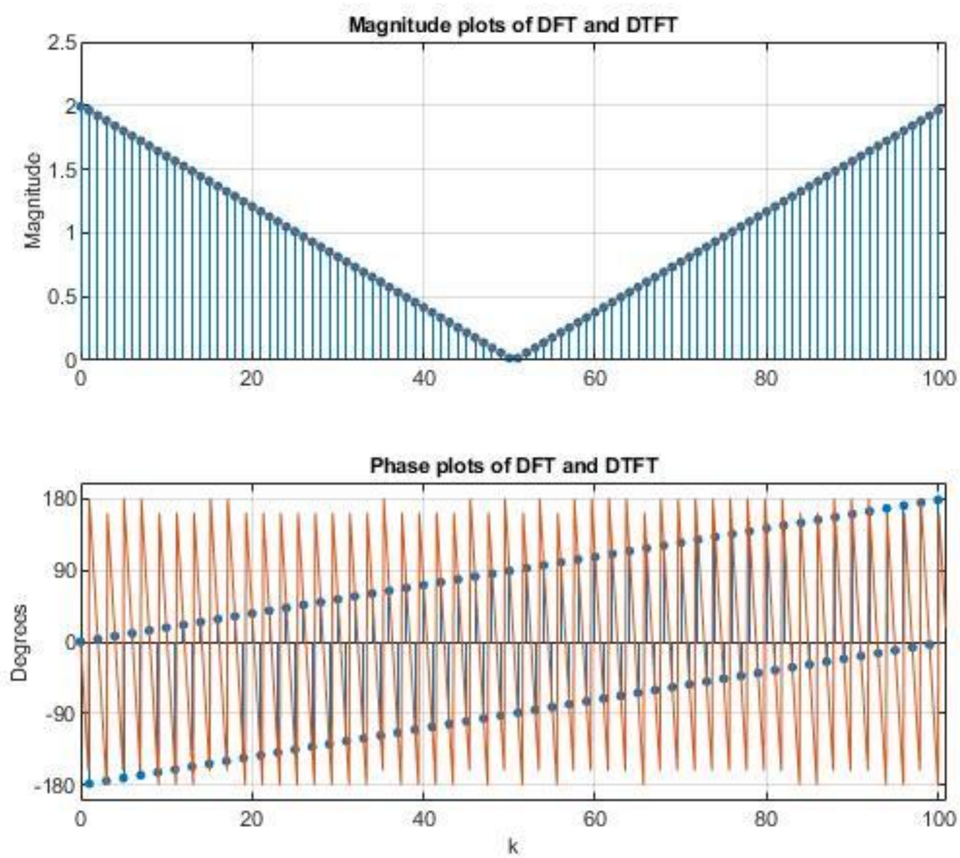


2.2

(Since the Matlab process of the code is too long) The MATLAB codes for the DTFT of x(n) is listed below briefly.

```
>> [X,w] = freqz(xn,1,1000,'whole')
>> mag_X = abs(X)
>> pha_X = angle(X)*180/pi
>> Dw = (2*pi)/N
>> subplot(2,1,1)
>> plot(w/Dw,mag_X)
>> grid
>> hold off
>> subplot(2,1,2)
>> plot(w/Dw,pha_X)
>> grid
>> hold off
```

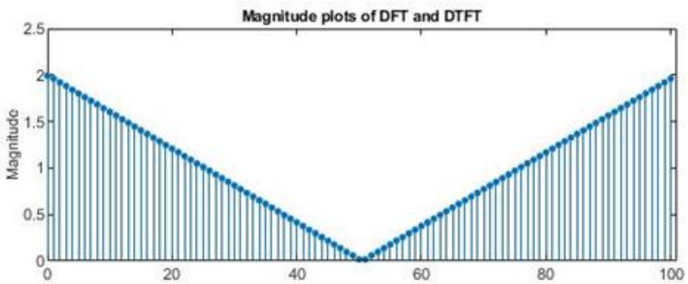
Continuous plot of DTFT of x(n)

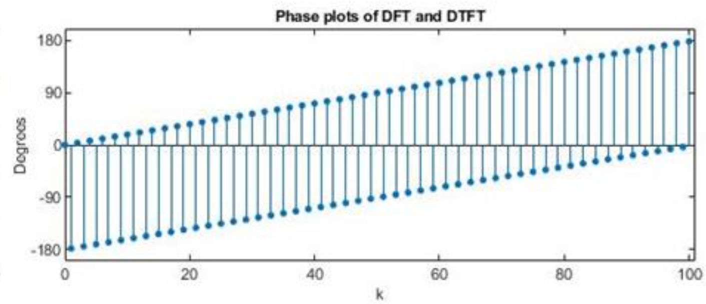


3.

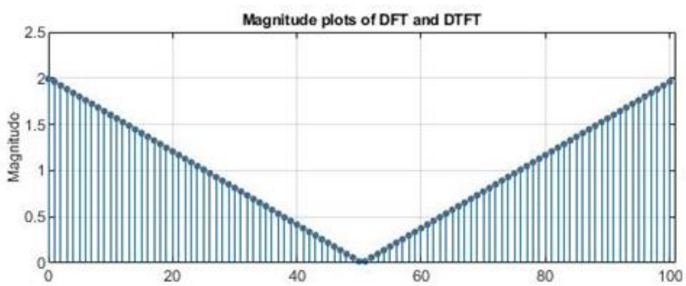
By comparing both plots that we have obtained, shown below are the Manitude and Phase plots of the transforms, here it is apparent that the DFT of x(n) is the sampled version of the DTFT of x(n).

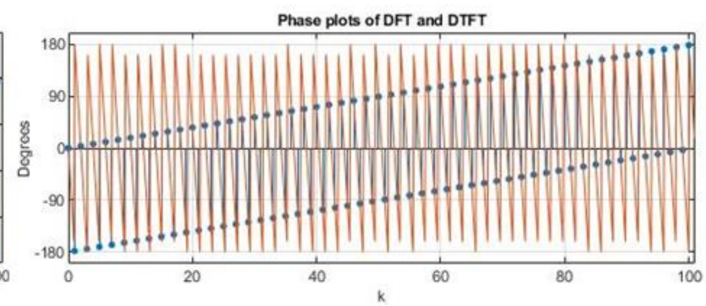
DFT of x(n)





DTFT of x(n)





4.

It is possible only if length of the DFT is larger than or equal to the length of sequence *x* (*n*), by the use of the complex interpolation formula we could get:

$$X(e^{j\omega}) = \sum_{k=0}^{N-1} x(k)\,\Phi\left(\omega - \frac{2\pi k}{N}\right)$$

Where $\Phi(\omega) = e^{-j\omega(N-1)/2} \cdot \dfrac{\sin(\omega N/2)}{N \sin(\omega/2)}$

For $N = 101$; Hence

$$X(e^{j\omega}) = \sum_{k=0}^{100} x(k)\, e^{-j(50)\omega} \cdot \frac{\sin(50.5\omega)}{101 \sin(\omega/2)}$$

No.3

Using MATLAB to simulate the equation and obtain the necessary values for the cascaded form structure

MATLAB Command Window

```
>> % JEPH MARI M. DALIGDIG BS-ECE

>> % ECE104.1 LAB 2

>> b=[1 -3 11 -27 18]

b =

    1   -3    11   -27    18

>> a=[14 10 2 -4 -1] a =
```

```
   14    10     2    -4    -1
>> [b0,B,A]=dir2cas(b,a)
b0 =
   0.0714

B =

   1.0000   -0.0000    9.0000

   1.0000   -3.0000
2.0000 A =

   1.0000    0.9978    0.5545

   1.0000   -0.2835   -
0.1288 >> delta =
impseq(0,0,7) delta =

  1×8 logical array

   1   0   0   0   0   0   0   0

>> format long

>>
hcas=casfiltr(b0,B,A,delta)
hcas =

  Columns 1 through 7

   0.071428571428571  -0.265306122448980   0.965014577259475  -2.559558517284466

2.905411435711310  -1.452874652568230  -0.039663988401333

  Column 8


0.883176886765
036 >>
hdir=filter(b,a,del
ta) hdir =

  Columns 1 through 7

   0.071428571428571  -0.265306122448980   0.965014577259475  -2.559558517284465

2.905411435711311  -1.452874652568233  -0.039663988401334

  Column 8

   0.883176886765042
```

Cascaded form structure of

$14y(n) + 10y(n-1) + 2y(n-2) - 4y(n-3) - y(n-4) = x(n) - 3x(n-1) + 11x(n-2) - 27x(n-3) + 18x(n-4)$