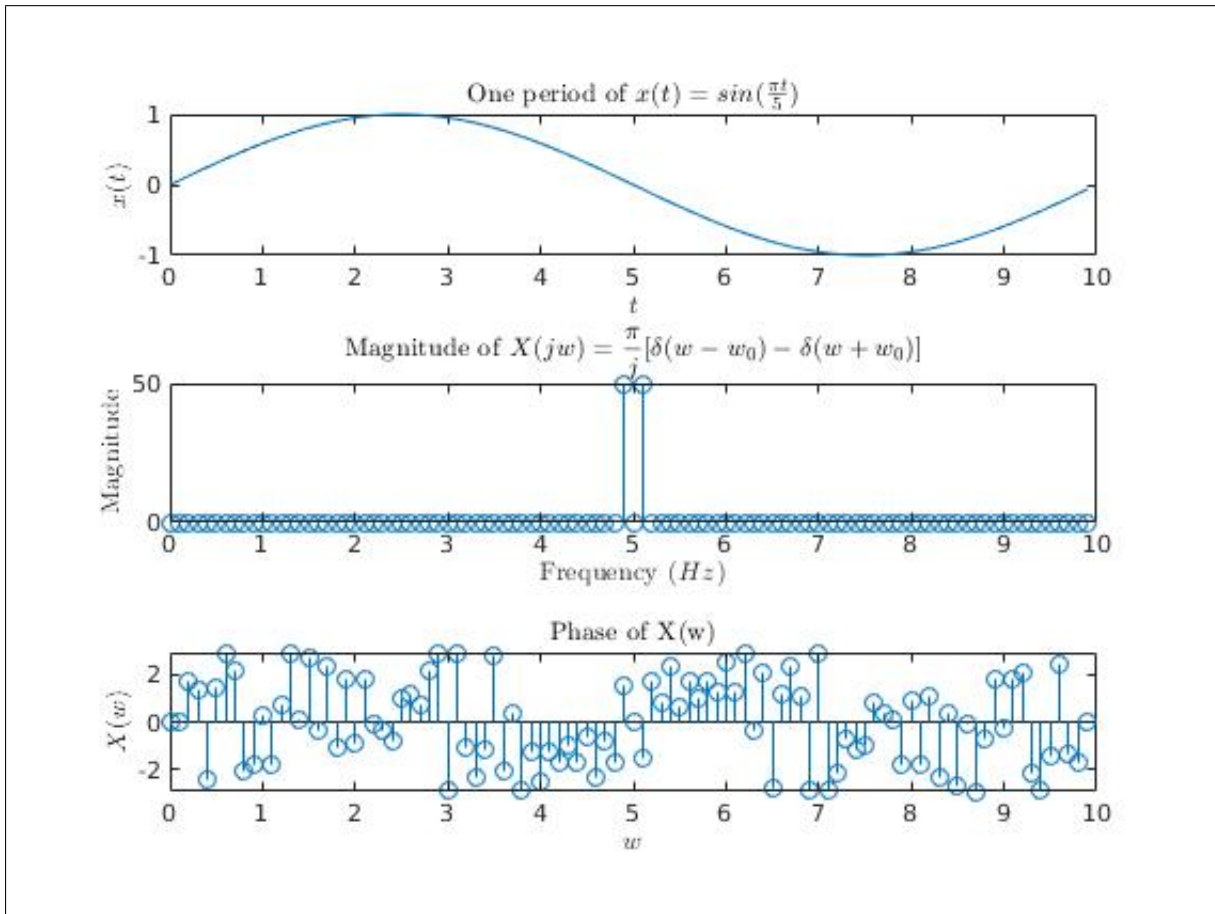


ECEN 220 Lab 3

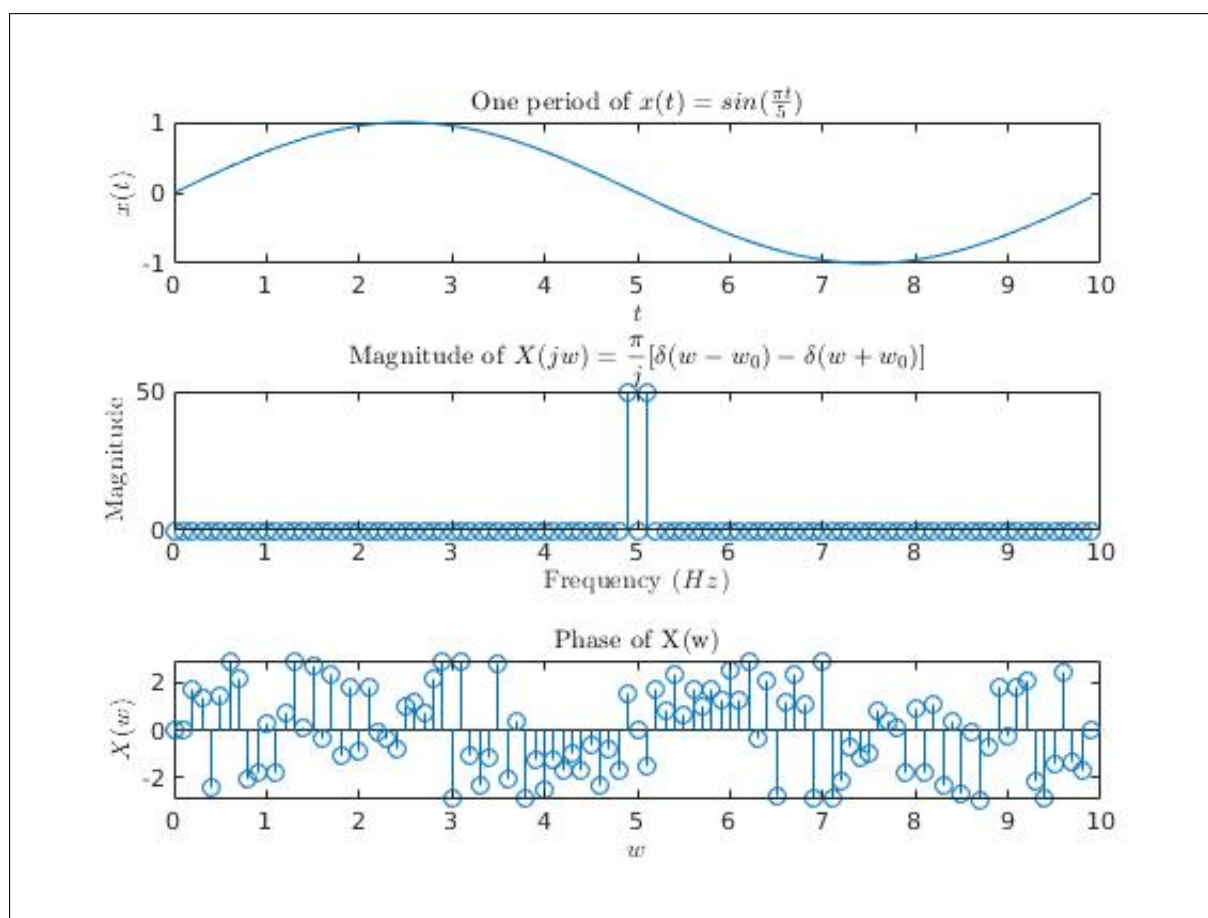
Niels Clayton
300437590

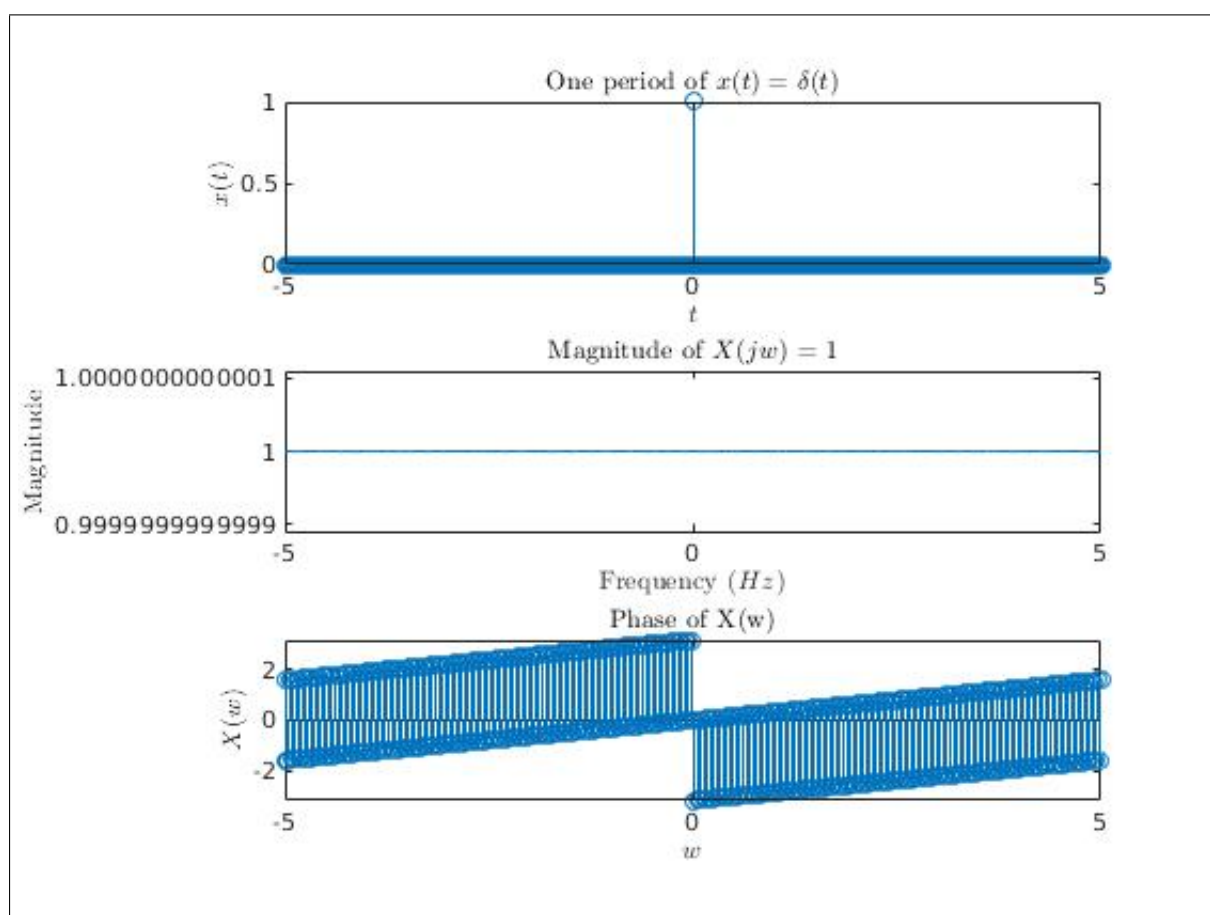
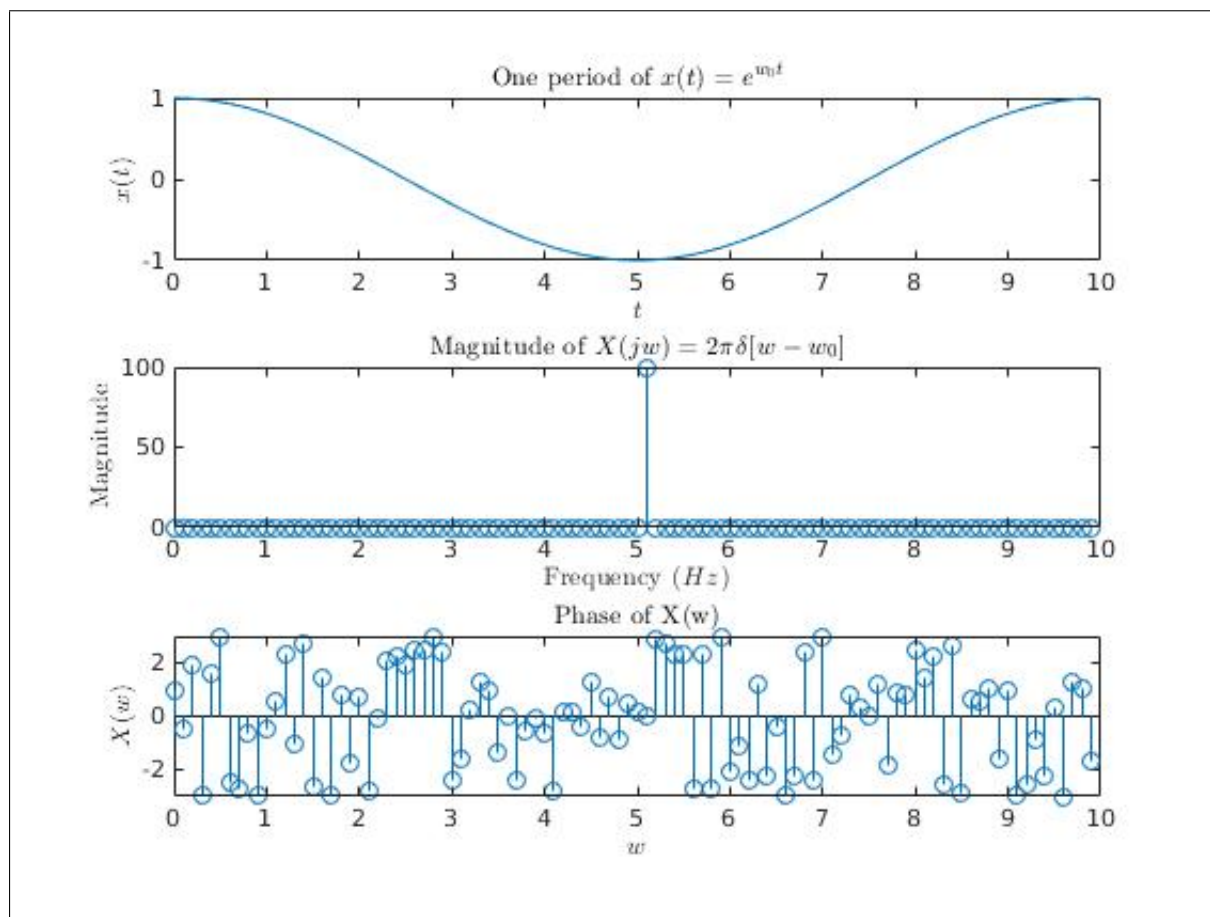
Part 1: Matlab Fourier Transform $\cos(w_0 t)$

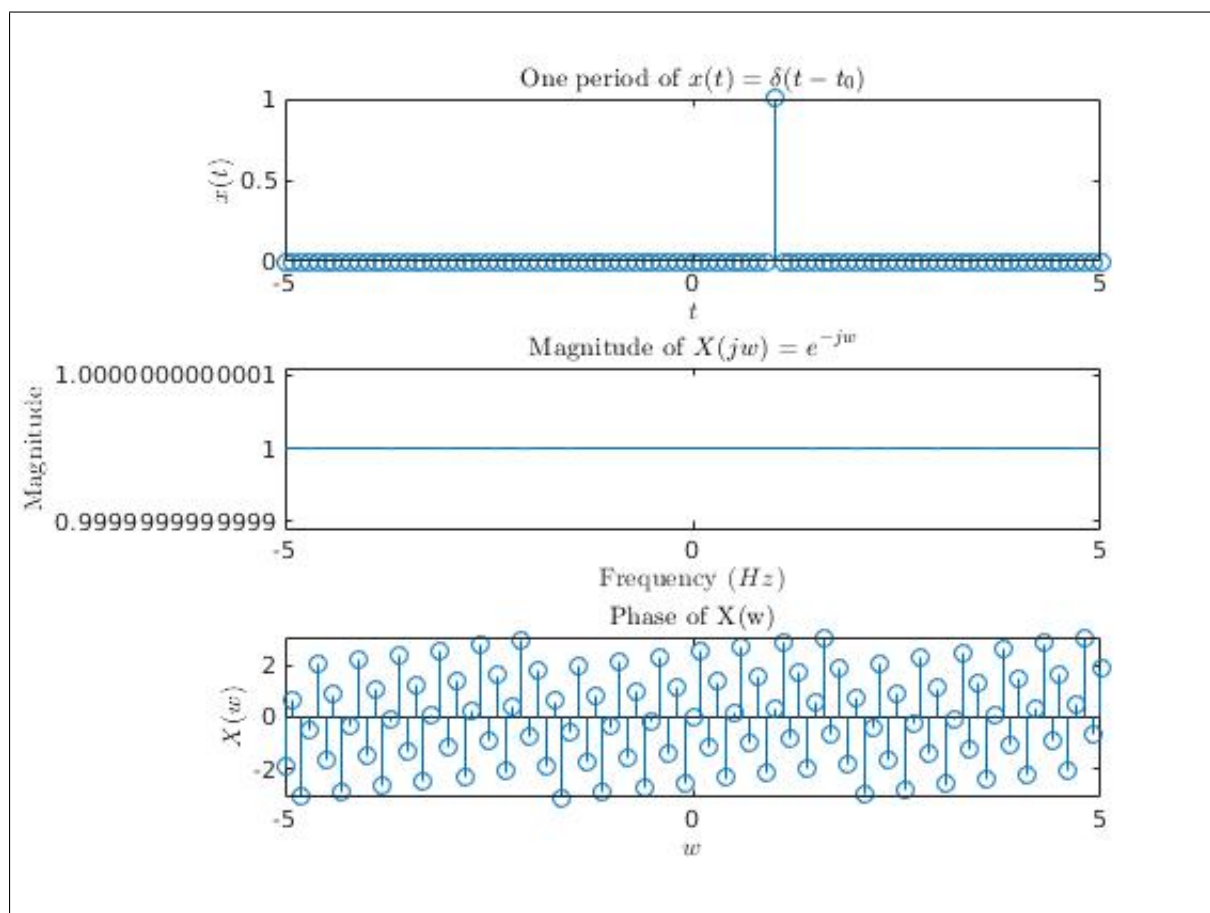
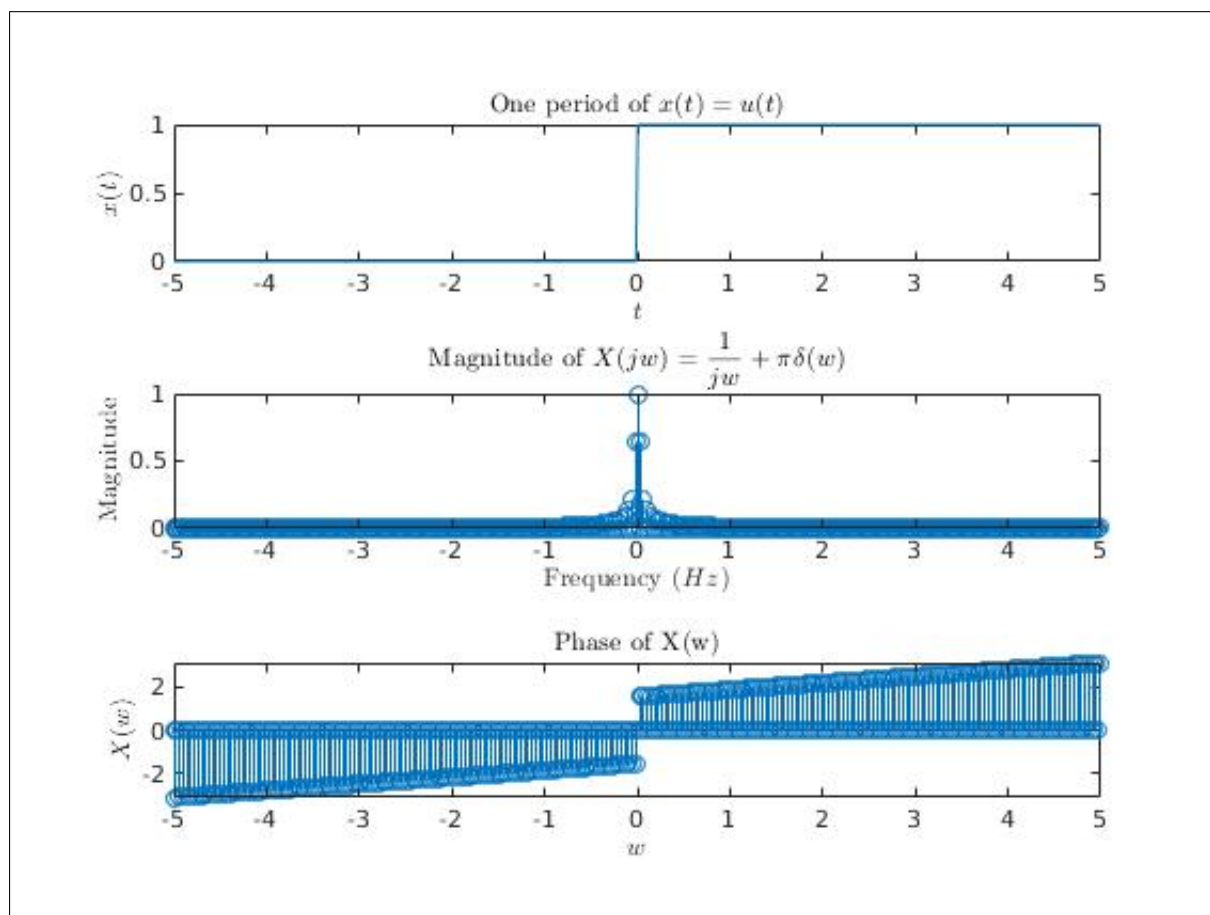


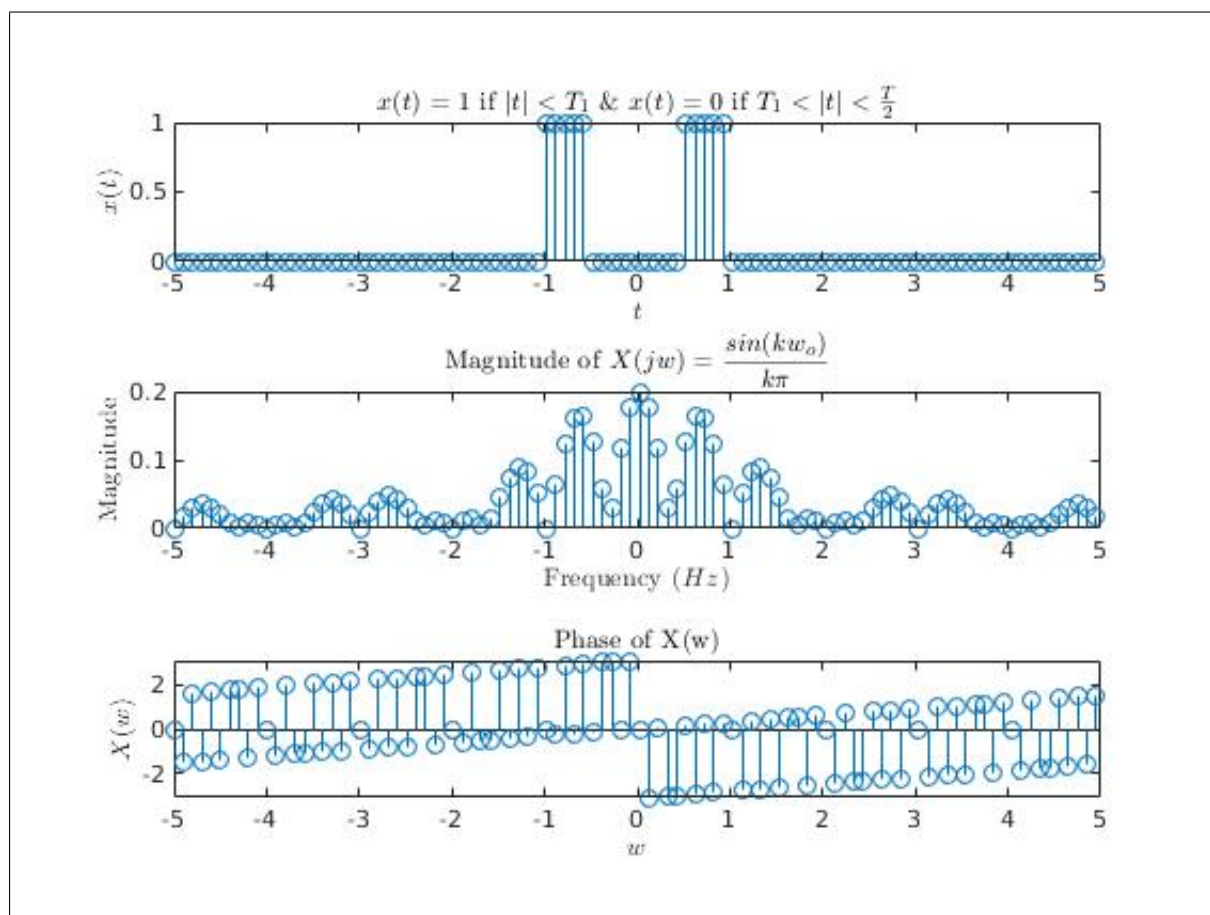
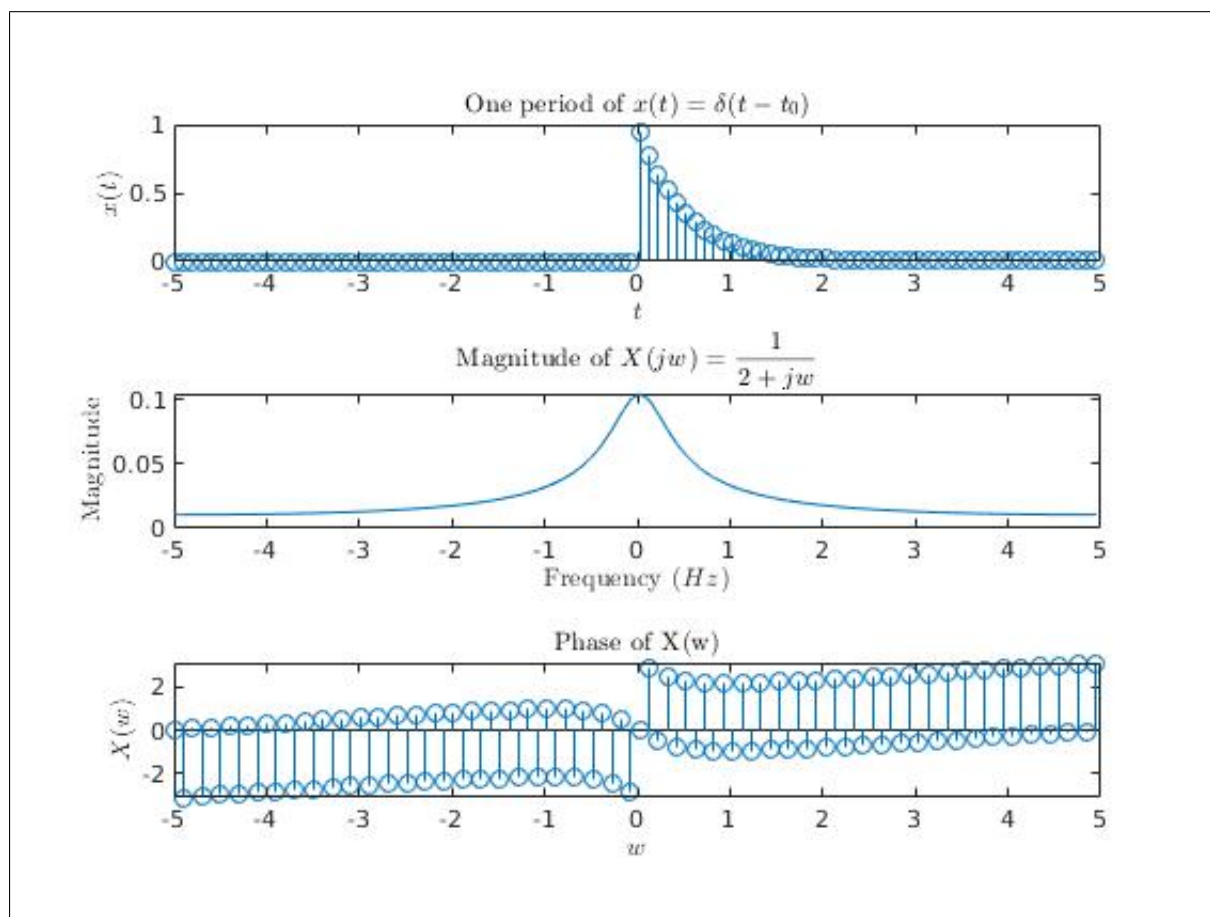
$\cos(x)$ is an even function, this means that when taking the Fourier transform of it, the result should be purely real. This means that we expect to see two peaks on the frequency spectrum of w_0 and $-w_0$, and for there to be zero phase. We do observe the expected peaks in frequency, however we don't observe the expected phases. This is do to floating point errors within a computer. When you manually look at the values of $X(jw)$ we can see that they all contain an imaginary component of the magnitude of 1×10^{-17} . This imaginary component is almost non-existent, however it does still have a phase, leading to the noise seen.

Part 2: Matlab Fourier Transform of other functions









Matlab Code

```

1 %% Question 1
2 clc , clear
3
4 % generate one period of the signal
5
6 F_s = 10; % Sample rate
7 Ts = 1/F_s; % Period of a sample
8 T = 10; % period of the signal
9
10 N = T.*F_s; % Number of samples total
11 t = linspace(0, T-Ts, N); % Values of t to sample at
12
13 w_0 = 2*pi/T;
14 x = cos(w_0*t);
15
16 subplot(3, 1, 1);
17 plot(t, x);
18 title('One period of  $x(t)=\cos(\frac{\pi t}{5})$ ', 'interpreter', '
    latex')
19 xlabel('t', 'interpreter', 'latex')
20 ylabel('x(t)', 'interpreter', 'latex')
21
22 w = (-N/2:N/2-1)*(F_s/N); % The range on which the frequency will
    be plotted
23 X = fftshift(fft(x)); % Compute the fourier transform of x
24
25
26 subplot(3,1,2);
27 stem(t, abs(X/N)*2);
28 title("Magnitude of X(w)", 'interpreter', 'latex')
29 xlabel('Frequency $(Hz)$', 'interpreter', 'latex')
30 ylabel('Magnitude', 'interpreter', 'latex')
31
32 subplot(3,1,3);
33 stem(t, angle(X/N));
34 title("Phase of X(w)", 'interpreter', 'latex')
35 xlabel('w', 'interpreter', 'latex')
36 ylabel('X(w)', 'interpreter', 'latex')
37
38
39 %% Question 2 sin(x)
40 clc , clear
41
42 % generate one period of the signal
43
44 F_s = 10; % Sample rate
45 Ts = 1/F_s; % Period of a sample
46 T = 10; % period of the signal
47
48 N = T.*F_s; % Number of samples total

```



```

49 t = linspace(0, T-Ts, N);    % Values of t to sample at
50
51 w_0 = 2*pi/T;
52 x = sin(w_0*t);
53
54 subplot(3, 1, 1);
55 plot(t, x);
56 title('One period of  $x(t)=\sin(\frac{\pi t}{5})$ ', 'interpreter', '
    latex')
57 xlabel('t', 'interpreter', 'latex')
58 ylabel('x(t)', 'interpreter', 'latex')
59
60 w = (-N/2:N/2-1)*(F_s/N);    % The range on which the frequency will
    be plotted
61 X = fftshift(fft(x));        % Compute the fourier transform of x
62
63
64 subplot(3,1,2);
65 stem(t, abs(X));
66 title("Magnitude of  $X(jw)=\frac{\pi}{j}[\delta(w-w_0)-\delta(w+w_0)]$ ", 'interpreter', 'latex')
67 xlabel('Frequency (Hz)', 'interpreter', 'latex')
68 ylabel('Magnitude', 'interpreter', 'latex')
69
70 subplot(3,1,3);
71 stem(t, angle(X/N));
72 title("Phase of X(w)", 'interpreter', 'latex')
73 xlabel('w', 'interpreter', 'latex')
74 ylabel('X(w)', 'interpreter', 'latex')
75
76 %% Question 2 exponential
77 clc, clear
78
79 % generate one period of the signal
80
81 F_s = 10;                    % Sample rate
82 Ts = 1/F_s;                  % Period of a sample
83 T = 10;                      % period of the signal
84
85 N = T.*F_s;                  % Number of samples total
86 t = linspace(0, T-Ts, N);    % Values of t to sample at
87
88 w_0 = 2*pi/T;
89 x = exp(1i.*w_0.*t);
90
91 subplot(3, 1, 1);
92 plot(t, x);
93 title('One period of  $x(t)=e^{jw_0 t}$ ', 'interpreter', 'latex')
94 xlabel('t', 'interpreter', 'latex')
95 ylabel('x(t)', 'interpreter', 'latex')
96
97 w = (-N/2:N/2-1)*(F_s/N);    % The range on which the frequency will

```

```

        be plotted
98 X = fftshift(fft(x));           % Compute the fourier transform of x
99
100
101 subplot(3,1,2);
102 stem(t,abs(X));
103 title("Magnitude of  $X(j\omega)=2\pi \delta[\omega-\omega_0]$ ", 'interpreter','latex')
104 xlabel('Frequency $(Hz)$', 'interpreter','latex')
105 ylabel('Magnitude', 'interpreter','latex')
106
107 subplot(3,1,3);
108 stem(t,angle(X/N));
109 title("Phase of  $X(\omega)$ ", 'interpreter','latex')
110 xlabel(''$\omega$$', 'interpreter','latex')
111 ylabel(''$X(\omega)$$', 'interpreter','latex')
112
113 %% Question 2 delta
114 clc, clear
115
116 % generate one period of the signal
117
118 F_s = 101;           % Sample rate
119 T_s = 1/F_s;         % Period of a sample
120 T = 5;               % period of the signal
121
122 N = T.*F_s;          % Number of samples total
123 t = linspace(-5, T, N); % Values of t to sample at
124
125 x = (t==0);
126
127 subplot(3, 1, 1);
128 stem(t, x);
129 title('One period of  $x(t)=\delta(t)$ ', 'interpreter','latex')
130 xlabel(''$t$$', 'interpreter','latex')
131 ylabel(''$x(t)$$', 'interpreter','latex')
132
133 w = (-N/2:N/2-1)*(F_s/N); % The range on which the frequency will
        be plotted
134 X = fftshift(fft(x));     % Compute the fourier transform of x
135
136
137 subplot(3,1,2);
138 plot(t,abs(X));
139 title("Magnitude of  $X(j\omega)=1$ ", 'interpreter','latex')
140 xlabel('Frequency $(Hz)$', 'interpreter','latex')
141 ylabel('Magnitude', 'interpreter','latex')
142
143 subplot(3,1,3);
144 stem(t,angle(X/N));
145 title("Phase of  $X(\omega)$ ", 'interpreter','latex')
146 xlabel(''$\omega$$', 'interpreter','latex')

```



```

147 ylabel( '$$X(w)$$', 'interpreter', 'latex')
148
149 %% Question 2 Unit step
150 clc, clear
151
152 % generate one period of the signal
153
154 F_s = 100; % Sample rate
155 Ts = 1/F_s; % Period of a sample
156 T = 5; % period of the signal
157
158 N = T.*F_s; % Number of samples total
159 t = linspace(-5, T-Ts, N); % Values of t to sample at
160
161 w_0 = 2*pi/T;
162 x = (t >= 0);
163
164 subplot(3, 1, 1);
165 plot(t, x);
166 title('One period of  $x(t) = u(t)$ ', 'interpreter', 'latex')
167 xlabel('$$t$$', 'interpreter', 'latex')
168 ylabel('$$x(t)$$', 'interpreter', 'latex')
169
170 w = (-N/2:N/2-1)*(F_s/N); % The range on which the frequency will
    be plotted
171 X = fftshift(fft(x)); % Compute the fourier transform of x
172
173
174 subplot(3, 1, 2);
175 stem(t, abs(X/N)*2);
176 title("Magnitude of  $X(jw) = \frac{1}{jw} + \pi \delta(w)$ ", 'interpreter', 'latex')
177 xlabel('Frequency $(Hz)$', 'interpreter', 'latex')
178 ylabel('Magnitude', 'interpreter', 'latex')
179
180 subplot(3, 1, 3);
181 stem(t, angle(X/N));
182 title("Phase of  $X(w)$ ", 'interpreter', 'latex')
183 xlabel('$$w$$', 'interpreter', 'latex')
184 ylabel('$$X(w)$$', 'interpreter', 'latex')
185
186 %% Question 2 delta shifted
187 clc, clear
188
189 % generate one period of the signal
190
191 F_s = 10; % Sample rate
192 T = 10; % period of the signal
193
194 N = T.*F_s; % Number of samples total
195 t = linspace(-5, 5, 101); % Values of t to sample at
196

```

```

197 x = (t==1);
198
199 subplot(3, 1, 1);
200 stem(t, x);
201 title('One period of  $x(t) = \delta(t - t_0)$ ', 'interpreter', 'latex')
202 xlabel('t', 'interpreter', 'latex')
203 ylabel('x(t)', 'interpreter', 'latex')
204
205 w = (-N/2:N/2-1)*(F_s/N); % The range on which the frequency will
    be plotted
206 X = fftshift(fft(x)); % Compute the fourier transform of x
207
208 subplot(3,1,2);
209 plot(t, abs(X));
210 title("Magnitude of  $X(jw) = e^{-jw}$ ", 'interpreter', 'latex')
211 xlabel('Frequency (Hz)', 'interpreter', 'latex')
212 ylabel('Magnitude', 'interpreter', 'latex')
213
214 subplot(3,1,3);
215 stem(t, angle(X/N));
216 title("Phase of X(w)", 'interpreter', 'latex')
217 xlabel('w', 'interpreter', 'latex')
218 ylabel('X(w)', 'interpreter', 'latex')
219
220 %% Question 2 exp
221 clc, clear
222
223 % generate one period of the signal
224
225 F_s = 20; % Sample rate
226 Ts = 1/F_s; % Period of a sample
227 T = 5; % period of the signal
228
229 N = T.*F_s; % Number of samples total
230 t = linspace(-5, T-Ts, N); % Values of t to sample at
231 a = 2;
232
233 x = exp(-(a.*t)).*(t>=0);
234
235 subplot(3, 1, 1);
236 stem(t, x);
237 title('One period of  $x(t) = \delta(t - t_0)$ ', 'interpreter', 'latex')
238 xlabel('t', 'interpreter', 'latex')
239 ylabel('x(t)', 'interpreter', 'latex')
240
241 w = (-N/2:N/2-1)*(F_s/N); % The range on which the frequency will
    be plotted
242 X = fftshift(fft(x)); % Compute the fourier transform of x
243
244 subplot(3,1,2);
245 plot(t, abs(X/N)*2);
246 title("Magnitude of  $X(jw) = \frac{1}{2+jw}$ ", 'interpreter', 'latex')

```

```

247 xlabel('Frequency $(Hz)$','interpreter','latex')
248 ylabel('Magnitude','interpreter','latex')
249
250 subplot(3,1,3);
251 stem(t,angle(X/N));
252 title("Phase of X(w)","interpreter','latex')
253 xlabel('$$w$$','interpreter','latex')
254 ylabel('$$X(w)$$','interpreter','latex')
255
256
257 %% Question 2 piece wise
258 clc , clear
259
260 % generate one period of the signal
261
262 F_s = 20; % Sample rate
263 Ts = 1/F_s; % Period of a sample
264 T = 5; % period of the signal
265 T1 = 1;
266
267 N = T.*F_s; % Number of samples total
268 t = linspace(-5, T-Ts, N); % Values of t to sample at
269
270
271 x = (abs(t) < T1) - (abs(t) < T1/2);
272
273 subplot(3, 1, 1);
274 stem(t, x);
275 title('$x(t) = 1$ if $|t| < T_1$ \& $x(t) = 0$ if $T_1 < |t| < \frac{
T}{2}$','interpreter','latex')
276 xlabel('$$t$$','interpreter','latex')
277 ylabel('$$x(t)$$','interpreter','latex')
278
279 w = (-N/2:N/2-1)*(F_s/N); % The range on which the frequency will
    be plotted
280 X = fftshift(fft(x)); % Compute the fourier transform of x
281
282 subplot(3,1,2);
283 stem(t,abs(X/N)*2);
284 title("Magnitude of $$X(jw)=\frac{\sin(kw_o)}{k\pi}$$",'interpreter','
    latex')
285 xlabel('Frequency $(Hz)$','interpreter','latex')
286 ylabel('Magnitude','interpreter','latex')
287
288 subplot(3,1,3);
289 stem(t,angle(X/N));
290 title("Phase of X(w)","interpreter','latex')
291 xlabel('$$w$$','interpreter','latex')
292 ylabel('$$X(w)$$','interpreter','latex')

```