

ICS 311 Digital Signal Processing

Lab 7_SAMPLING THEOREM

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2021BCS0036

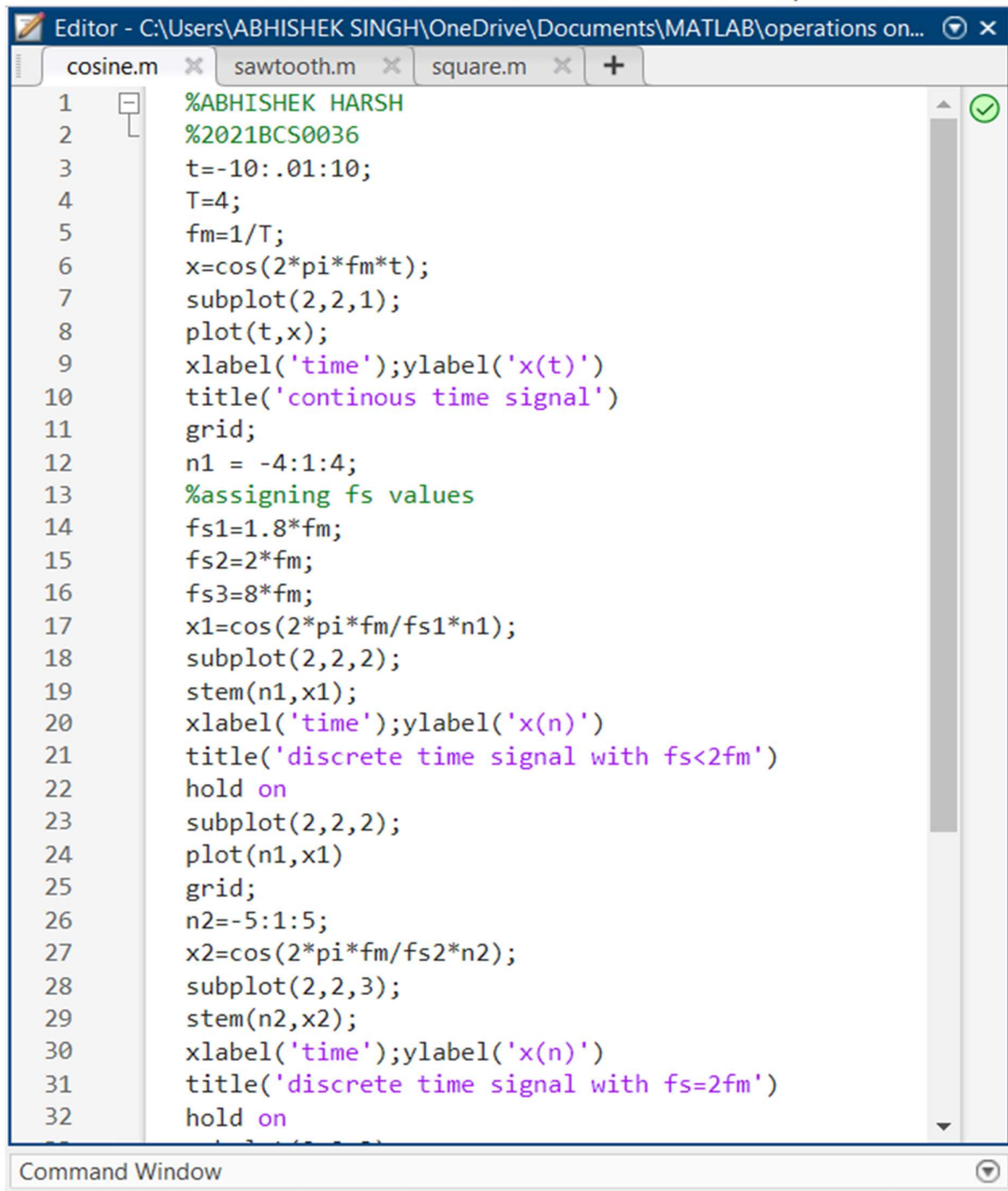
1. Verify sampling theorem for the following functions using Matlab program.

- Cosine wave
- Square wave
- Sawtooth wave
- Sine wave

1>Cosine Wave

Code:

Users ▸ ABHISHEK SINGH ▸ OneDrive ▸ Documents ▸ MATLAB ▸ operations on ▸ lab7



```
Editor - C:\Users\ABHISHEK SINGH\OneDrive\Documents\MATLAB\operations on...
cosine.m x sawtooth.m x square.m x +
1 %ABHISHEK HARSH
2 %2021BCS0036
3 t=-10:.01:10;
4 T=4;
5 fm=1/T;
6 x=cos(2*pi*fm*t);
7 subplot(2,2,1);
8 plot(t,x);
9 xlabel('time');ylabel('x(t)')
10 title('continous time signal')
11 grid;
12 n1 = -4:1:4;
13 %assigning fs values
14 fs1=1.8*fm;
15 fs2=2*fm;
16 fs3=8*fm;
17 x1=cos(2*pi*fm/fs1*n1);
18 subplot(2,2,2);
19 stem(n1,x1);
20 xlabel('time');ylabel('x(n)')
21 title('discrete time signal with fs<2fm')
22 hold on
23 subplot(2,2,2);
24 plot(n1,x1)
25 grid;
26 n2=-5:1:5;
27 x2=cos(2*pi*fm/fs2*n2);
28 subplot(2,2,3);
29 stem(n2,x2);
30 xlabel('time');ylabel('x(n)')
31 title('discrete time signal with fs=2fm')
32 hold on
```

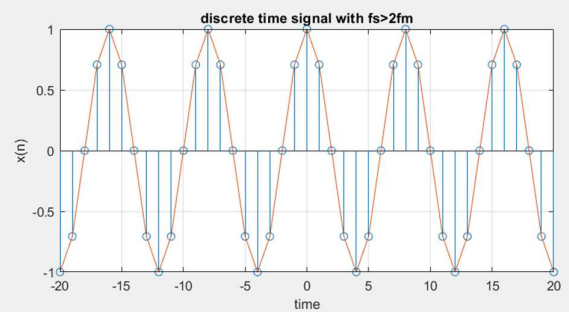
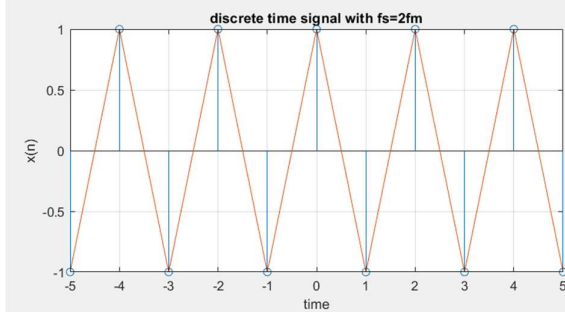
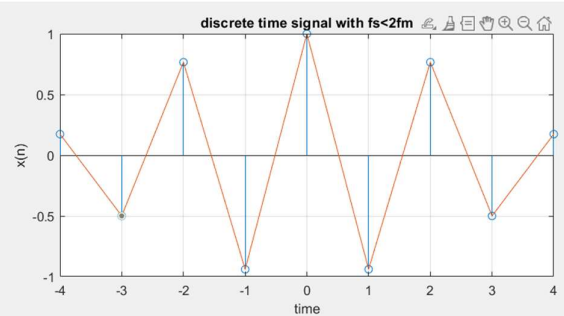
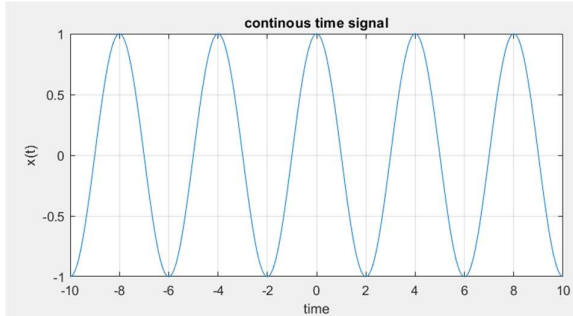
Command Window

```

31 title('discrete time signal with fs=2fm')
32 hold on
33 subplot(2,2,3);
34 plot(n2,x2)
35 grid;
36 n3=-20:1:20;
37 x3=cos(2*pi*fm/fs3*n3);
38 subplot(2,2,4);
39 stem(n3,x3);
40 xlabel('time');ylabel('x(n)')
41 title('discrete time signal with fs>2fm');
42 hold on
43 subplot(2,2,4);
44 plot(n3,x3)
45 grid;

```

Command Window



2>Square wave(Extra)

Code:

ABHISHEK SINGH ▸ OneDrive ▸ Documents ▸ MATLAB ▸ operations on ▸ lab7

```
Editor - C:\Users\ABHISHEK SINGH\OneDrive\Documents\MATLAB\operations on\lab7\square.m
cosine.m x sawtooth.m x square.m x +
1 %ABHISHEK HARSH
2 %2021BCS0036
3 t = -10:0.01:10;
4 T = 4;
5 fm = 1/T;
6
7 % Continuous-time square wave signal
8 x = square_wave(t, T, 0.5); % custom square_wave function with duty cycl 0.5
9 subplot(2,2,1);
10 plot(t, x);
11 xlabel('time'); ylabel('x(t)');
12 title('Continuous-time square wave signal');
13 grid;
14
15 n1 = -4:1:4;
16 % Assigning fs values
17 fs1 = 1.8*fm;
18 fs2 = 2*fm;
19 fs3 = 8*fm;
20
21 % Discrete-time square wave signals
22 x1 = square_wave(n1, T/fs1, 0.5);
23 subplot(2,2,2);
24 stem(n1, x1);
25 xlabel('time (n)'); ylabel('x(n)');
26 title('Discrete-time square wave signal with fs < 2fm');
27 hold on;
28 subplot(2,2,2);
29 plot(n1, x1);
30 grid;
31
32
```

Command Window

Zoom: 100%

LITE 0

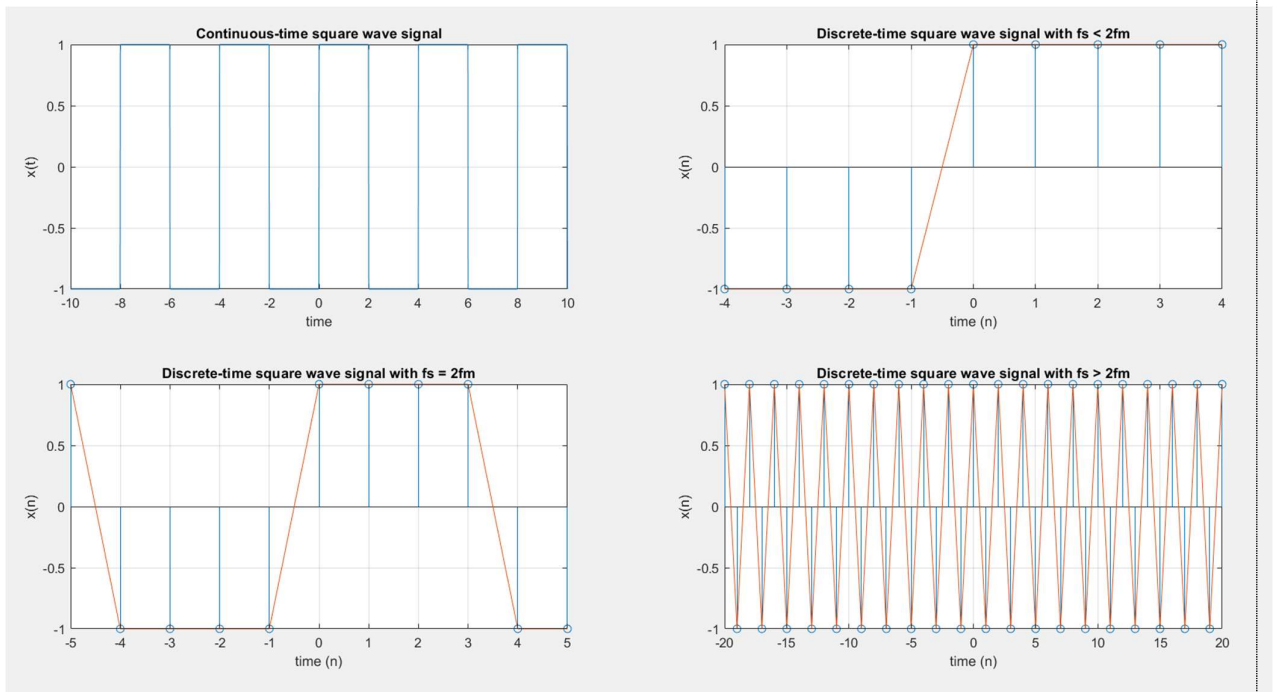
CPIE

script

In

```
ABHISHEK SINGH ▸ OneDrive ▸ Documents ▸ MATLAB ▸ operations on ▸ lab7
Editor - C:\Users\ABHISHEK SINGH\OneDrive\Documents\MATLAB\operations on\lab7\square.m
cosine.m x sawtooth.m x square.m x +
29 plot(n1, x1);
30 grid;
31
32 n2 = -5:1:5;
33 x2 = square_wave(n2, T/fs2, 0.5);
34 subplot(2,2,3);
35 stem(n2, x2);
36 xlabel('time (n)'); ylabel('x(n)');
37 title('Discrete-time square wave signal with fs = 2fm');
38 hold on;
39 subplot(2,2,3);
40 plot(n2, x2);
41 grid;
42
43 n3 = -20:1:20;
44 x3 = square_wave(n3, T/fs3, 0.5);
45 subplot(2,2,4);
46 stem(n3, x3);
47 xlabel('time (n)'); ylabel('x(n)');
48 title('Discrete-time square wave signal with fs > 2fm');
49 hold on;
50 subplot(2,2,4);
51 plot(n3, x3);
52 grid;
53
54 % Custom square_wave function
55 function y = square_wave(t, T, duty_cycle)
56     t_normalized = mod(t, T);
57     y = (t_normalized < T * duty_cycle) * 2 - 1;
58 end
59
```

Output:



3>Sawtooth Wave

Code:

```
Users > ABHISHEK SINGH > OneDrive > Documents > MATLAB > operations on > lab
Editor - C:\Users\ABHISHEK SINGH\OneDrive\Documents\MATLAB\operations on...
cosine.m x sawtooth.m * x square.m x +
1 t = -10:0.01:10;
2 T = 4;
3 fm = 1/T;
4
5 % Continuous-time sawtooth wave signal
6 x = sawtooth_wave(t, T); % Using a custom sawtooth_
7 subplot(2,2,1);
8 plot(t, x);
9 xlabel('time'); ylabel('x(t)');
10 title('Continuous-time sawtooth wave signal');
11 grid;
12
13 n1 = -4:1:4;
14 % Assigning fs values
15 fs1 = 1.8*fm;
16 fs2 = 2*fm;
17 fs3 = 8*fm;
18 %Abhishek harsh
19 %2021BCS0036
20 % Discrete-time sawtooth wave signals
21 x1 = sawtooth_wave(n1, T/fs1); % Using a custom saw
22 subplot(2,2,2);
23 stem(n1, x1);
24 xlabel('time (n)'); ylabel('x(n)');
25 title('Discrete-time sawtooth wave signal with fs <
26 hold on;
27 subplot(2,2,2);
28 plot(n1, x1);
29 grid;
30
```

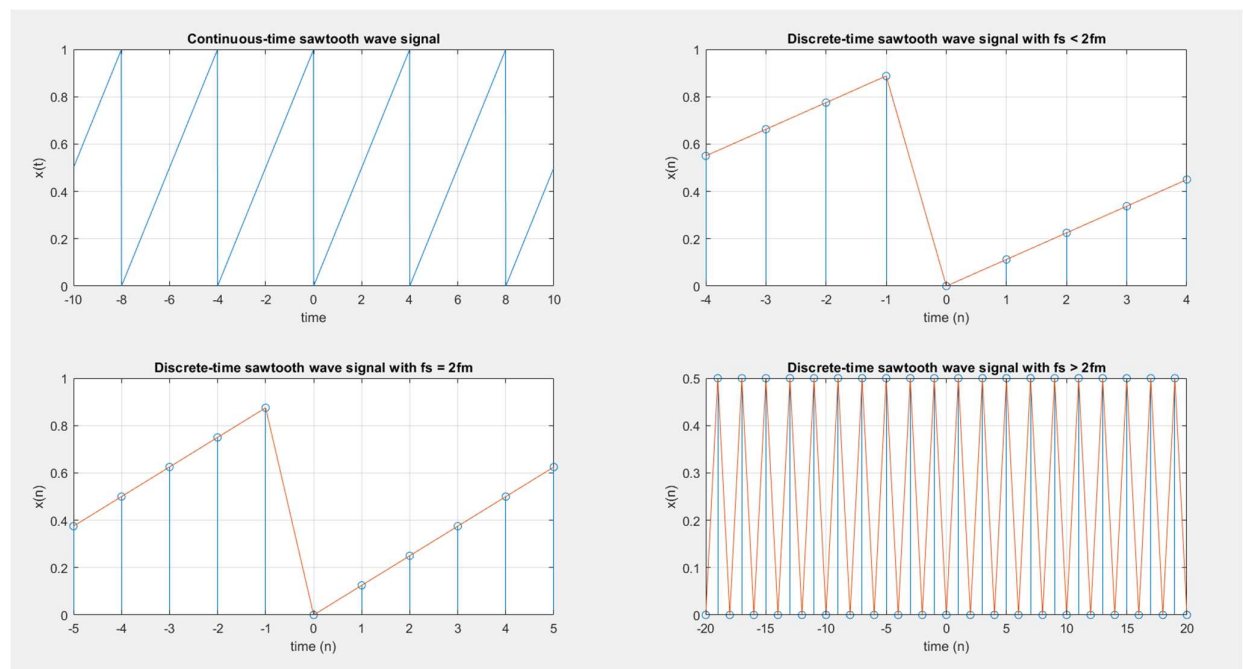


```

30
31     n2 = -5:1:5;
32     x2 = sawtooth_wave(n2, T/fs2); % Using a custom saw
33     subplot(2,2,3);
34     stem(n2, x2);
35     xlabel('time (n)'); ylabel('x(n)');
36     title('Discrete-time sawtooth wave signal with fs =
37     hold on;
38     subplot(2,2,3);
39     plot(n2, x2);
40     grid;
41
42     n3 = -20:1:20;
43     x3 = sawtooth_wave(n3, T/fs3); % Using a custom saw
44     subplot(2,2,4);
45     stem(n3, x3);
46     xlabel('time (n)'); ylabel('x(n)');
47     title('Discrete-time sawtooth wave signal with fs >
48     hold on;
49     subplot(2,2,4);
50     plot(n3, x3);
51     grid;
52
53     % Custom sawtooth_wave function
54     function y = sawtooth_wave(t, T)
55         y = mod(t, T) / T;
56     end
57

```

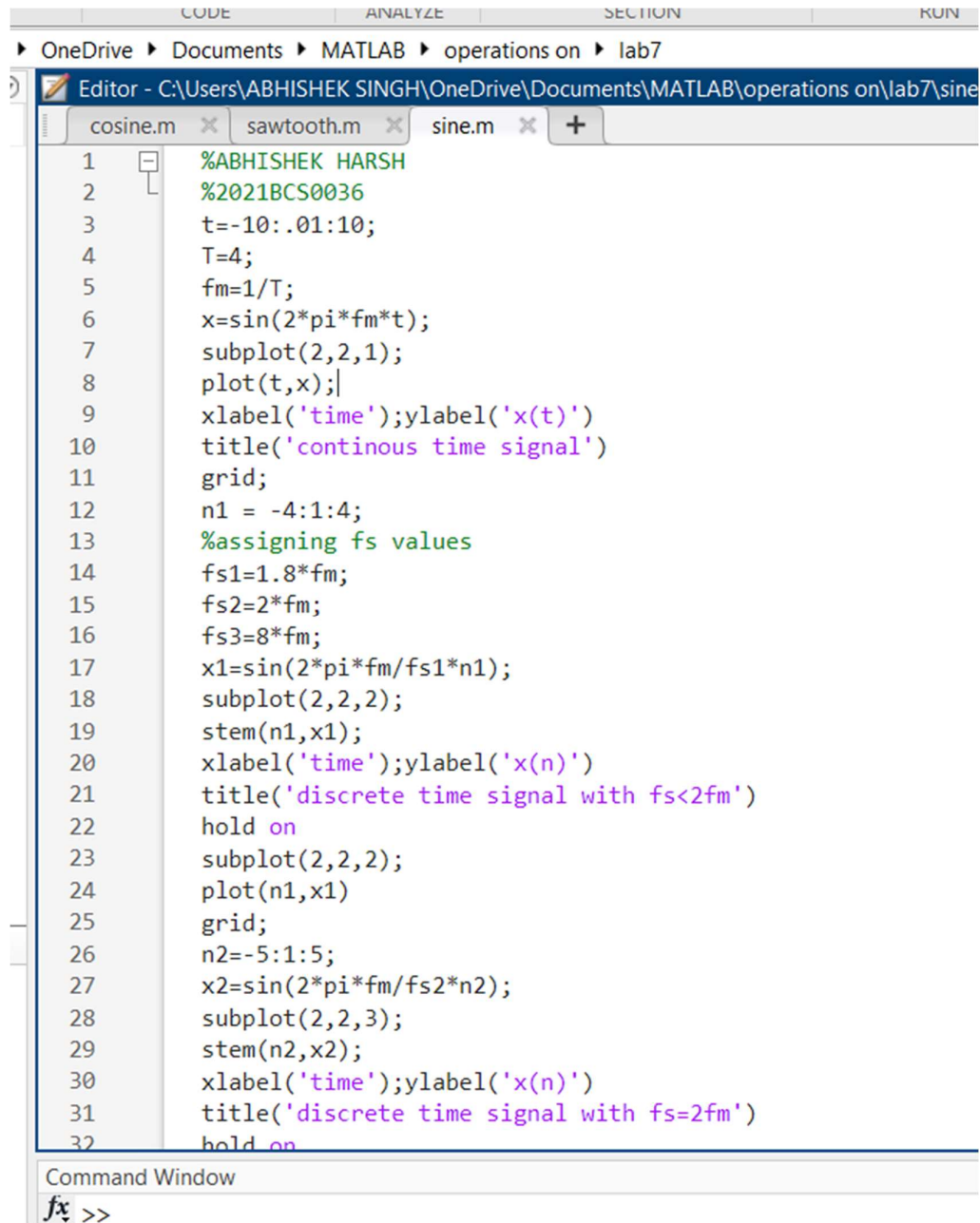
Output:



4>

Sine wave

Code:



```
CODE    ANALYZE    SECTION    RUN
▶ OneDrive ▶ Documents ▶ MATLAB ▶ operations on ▶ lab7
Editor - C:\Users\ABHISHEK SINGH\OneDrive\Documents\MATLAB\operations on\lab7\sine
cosine.m x sawtooth.m x sine.m x +
1 %ABHISHEK HARSH
2 %2021BCS0036
3 t=-10:.01:10;
4 T=4;
5 fm=1/T;
6 x=sin(2*pi*fm*t);
7 subplot(2,2,1);
8 plot(t,x);
9 xlabel('time');ylabel('x(t)')
10 title('continous time signal')
11 grid;
12 n1 = -4:1:4;
13 %assigning fs values
14 fs1=1.8*fm;
15 fs2=2*fm;
16 fs3=8*fm;
17 x1=sin(2*pi*fm/fs1*n1);
18 subplot(2,2,2);
19 stem(n1,x1);
20 xlabel('time');ylabel('x(n)')
21 title('discrete time signal with fs<2fm')
22 hold on
23 subplot(2,2,2);
24 plot(n1,x1)
25 grid;
26 n2=-5:1:5;
27 x2=sin(2*pi*fm/fs2*n2);
28 subplot(2,2,3);
29 stem(n2,x2);
30 xlabel('time');ylabel('x(n)')
31 title('discrete time signal with fs=2fm')
32 hold on
Command Window
fx >>
```

```

30 xlabel('time');ylabel('x(n)')
31 title('discrete time signal with fs=2fm')
32 hold on
33 subplot(2,2,3);
34 plot(n2,x2)
35 grid;
36 n3=-20:1:20;
37 x3=sin(2*pi*fm/fs3*n3);
38 subplot(2,2,4);
39 stem(n3,x3);
40 xlabel('time');ylabel('x(n)')
41 title('discrete time signal with fs>2fm');
42 hold on
43 subplot(2,2,4);
44 plot(n3,x3)
45 grid;

```

Command Window

Output

