

Problem 1

$$x[n] = 3 \cos\left(0.25\pi n + \frac{\pi}{3}\right) = 3 \cos\left(2\pi(0.125) + \frac{\pi}{3}\right)$$

a)

$$x_1(t) = A_1 \cos(2\pi f_1 t + \phi_1)$$

$$x_1[n] = A_1 \cos\left(2\pi \frac{n}{11000} + \phi_1\right), A_1 = 3, \phi_1 = \frac{\pi}{3}$$

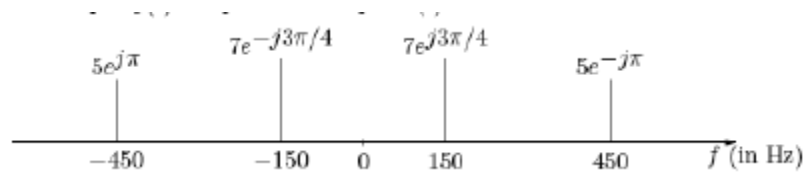
$$2\pi \frac{f_1}{11000} = 2\pi(0.125) \rightarrow f_1 = 1375 \text{ Hz}$$

$$2\pi \frac{f_2}{11000} = 2\pi(1 - 0.125) \rightarrow f_2 = 9625 \text{ Hz}$$

$$x_2(t) = A_2 \cos(2\pi(9625)t + \phi_2), A_2 = 3, \phi_2 = -\frac{\pi}{3}$$

b) The minimum sampling rate is equal to $2 * f_{\text{highest}}$ + a little bit to avoid aliasing. Therefore, the minimum sampling rate must be $2 * 450 \approx 900 \text{ Hz}$.

c)

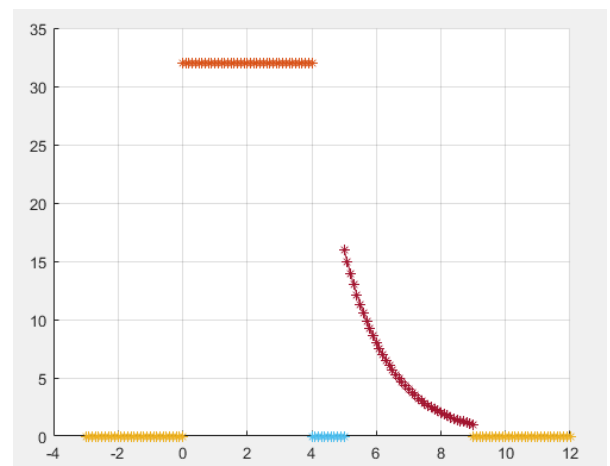


Problem 2

a)

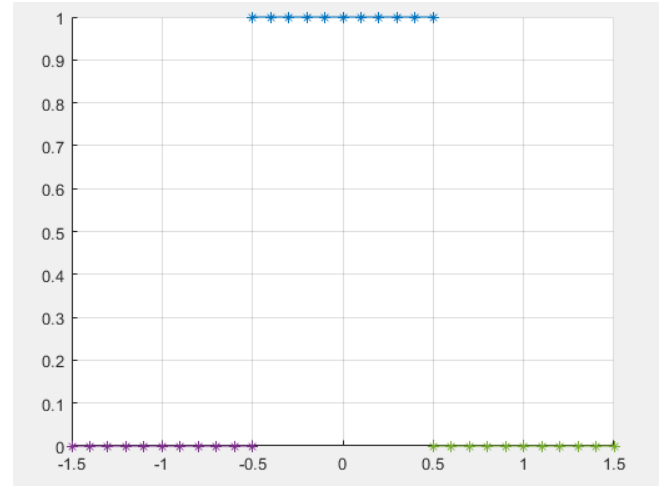
```
t1 = 0:.1:4;
t2 = 5:.1:9;
```

```
grid on; hold on
plot(-3:.1:0, zeros(length(-3:.1:0)), '*-')
plot(t1, 32*ones(length(t1)), '*-')
plot(4:.1:5, zeros(length(4:.1:5)), '*-')
plot(t2, (32.*0.5.^(t2-4)), '*-')
plot(9:.1:12, zeros(length(9:.1:12)), '*-')
```



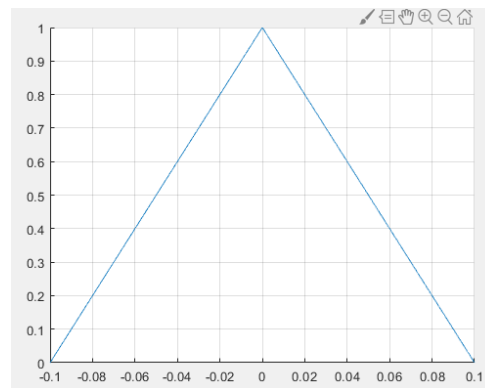
b)

```
tt = -0.5 : .1 : 0.5;  
  
grid on; hold on  
plot(-1.5:.1:-0.5, zeros(length(-1.5:.1:-0.5)),  
     '*_')  
plot(tt, ones(length(tt)), '*_')  
plot(0.5:.1:1.5, zeros(length(0.5:.1:1.5)), '*_')
```



c)

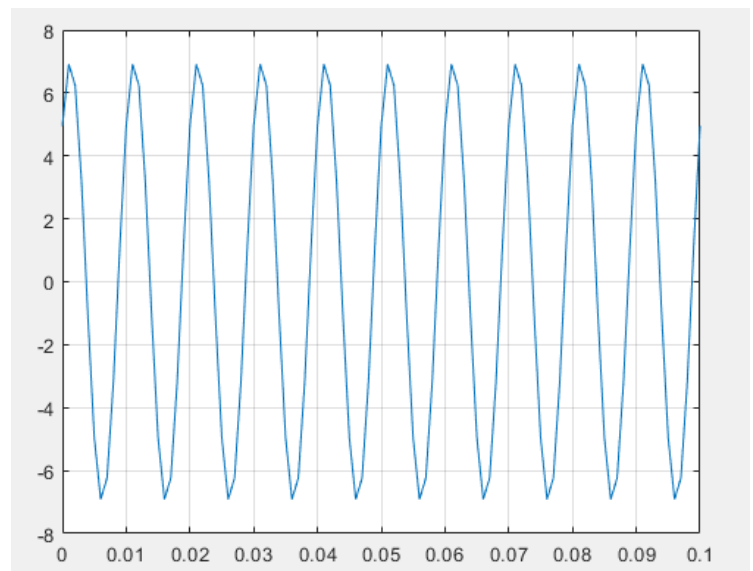
```
tt = -0.1 : .00001 : 0.1;  
  
grid on; hold on  
plot(tt, 1-10.*abs(tt))
```



Problem 3

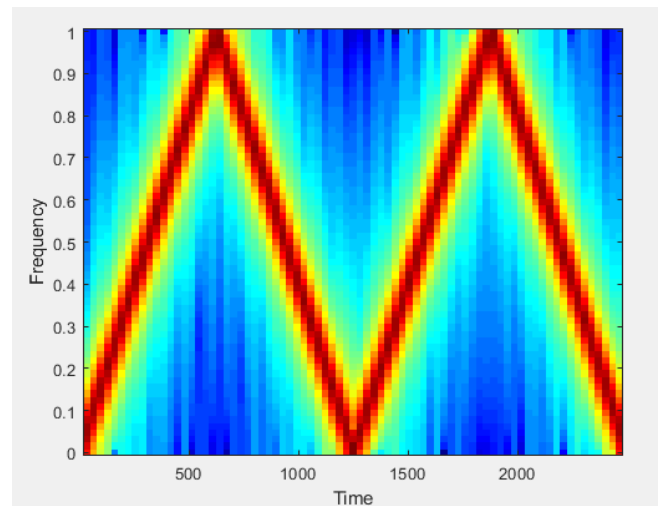
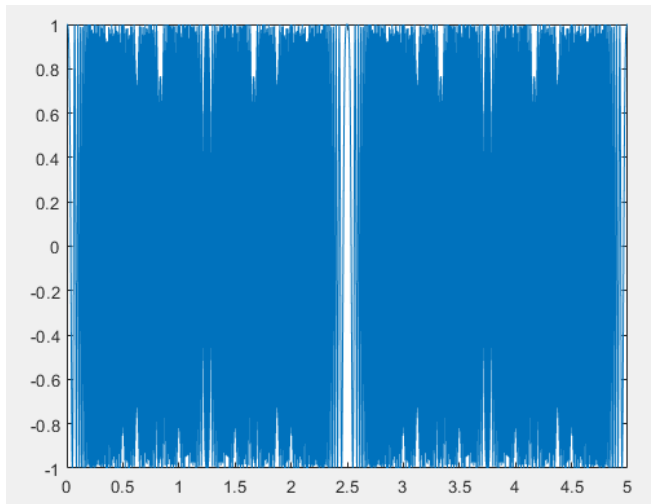
a)

```
fs = 1000;  
  
tt = 0:1/fs:.1;  
xx = 7*cos(1800*pi*tt + (pi/4));  
  
plot(tt, xx)  
grid on
```



b)

```
t2 = 0 : 1/1000 : 5;  
x2 = cos(2000 .* pi .* t2 - 400 .* pi .* t2.^2);  
figure  
plot(t2,x2)  
figure  
specgram(x2,128)
```



Problem 4

a) The sampling frequency is at least twice the maximum frequency – i.e. there is no aliasing/no lost information between $x(t)$ and $y(t)$.

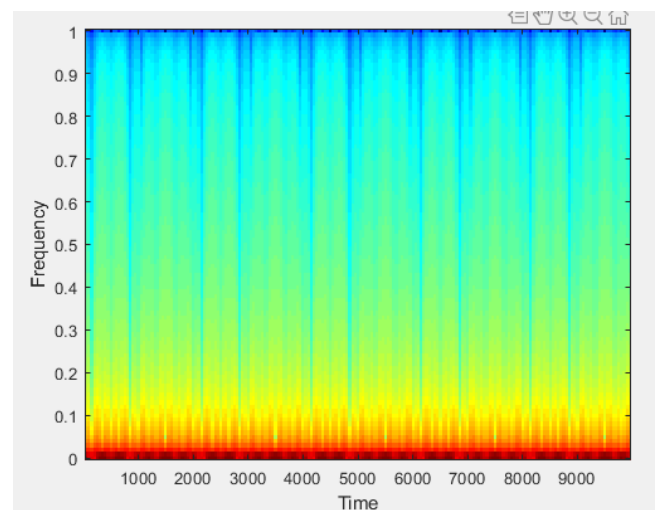
b)

```
t1 = 0 : 1/2000 : .1;  
x1 = 3 * cos(2*pi*50*t1 - pi/2) + 2*cos(2*pi*300*t1);
```

```
t2 = 0 : 1/200000 : .1;  
x2 = 3 * cos(2*pi*50*t2 - pi/2) +  
2*cos(2*pi*300*t2);
```

```
hold on  
plot(t1, x1)  
plot(t2, x2)  
grid on
```

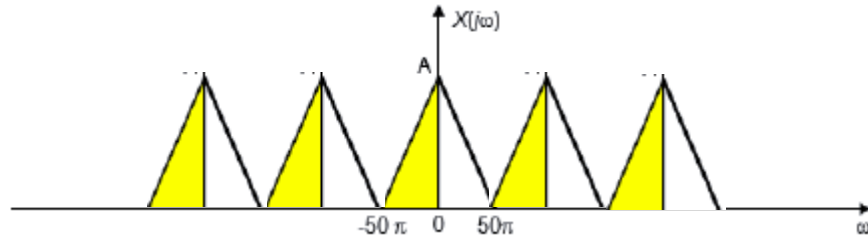
```
specgram(x2, 200)
```



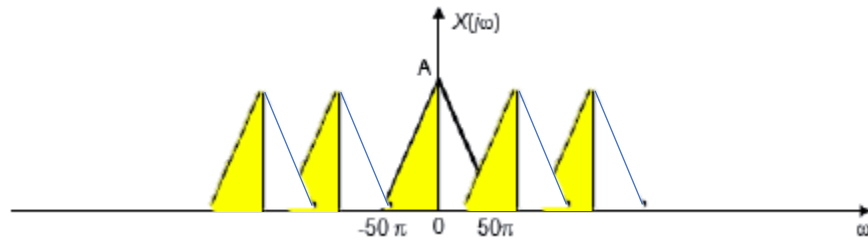
c) If the sampling rate is less than the Nyquist rate ($f_s < 2 * f_{max} \rightarrow f_s < 2 * 50\text{Hz}$)

Problem 5

a) Sampling frequency must be at least $2 * 50\pi \rightarrow \omega \geq 100\pi$



b)

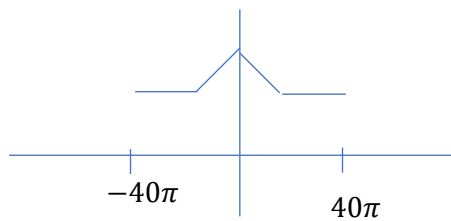


c)

$$\omega_s = \frac{2\pi}{T_s} = 80\pi$$

$$T_s = 0.025$$

$$H_r(j\omega) = \begin{cases} 0.025 & |\omega| \leq 40\pi \\ 0 & |\omega| > 40\pi \end{cases}$$



Problem 6

ai) $= e^{-j3\omega}$

a ii) $= \frac{1}{2}e^{j\omega} + 1 + \frac{1}{2}e^{-j\omega}$

a iii) $= \frac{1}{1 - \frac{1}{4}e^{-j-3}}$

a iv) $e^{j3\omega} \frac{1}{1 - e^{-j\omega}} - e^{-j4\omega} \frac{1}{1 - e^{-j\omega}}$