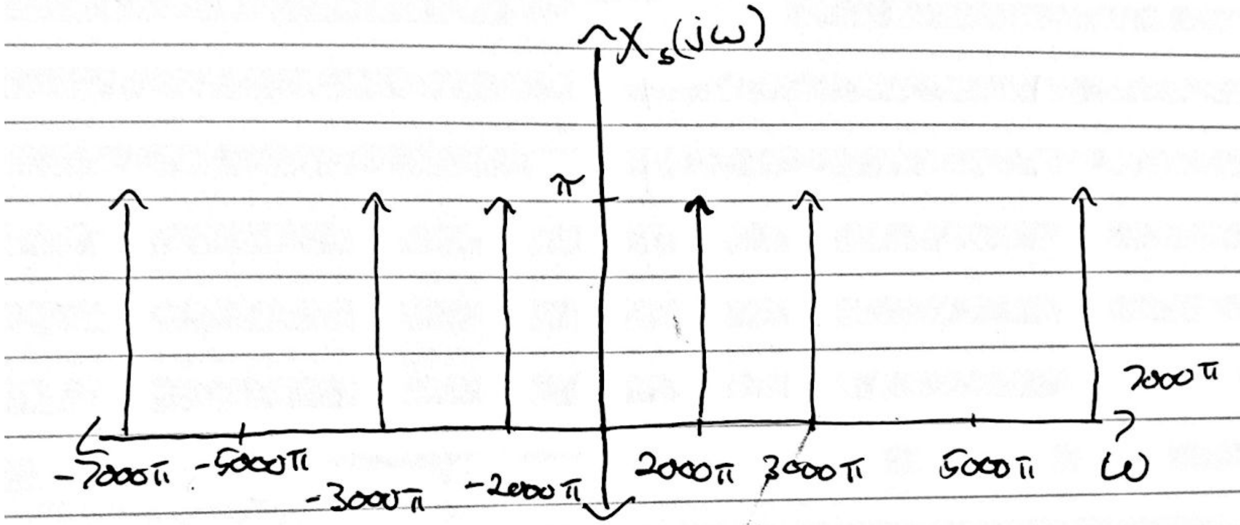
DSP Project 1

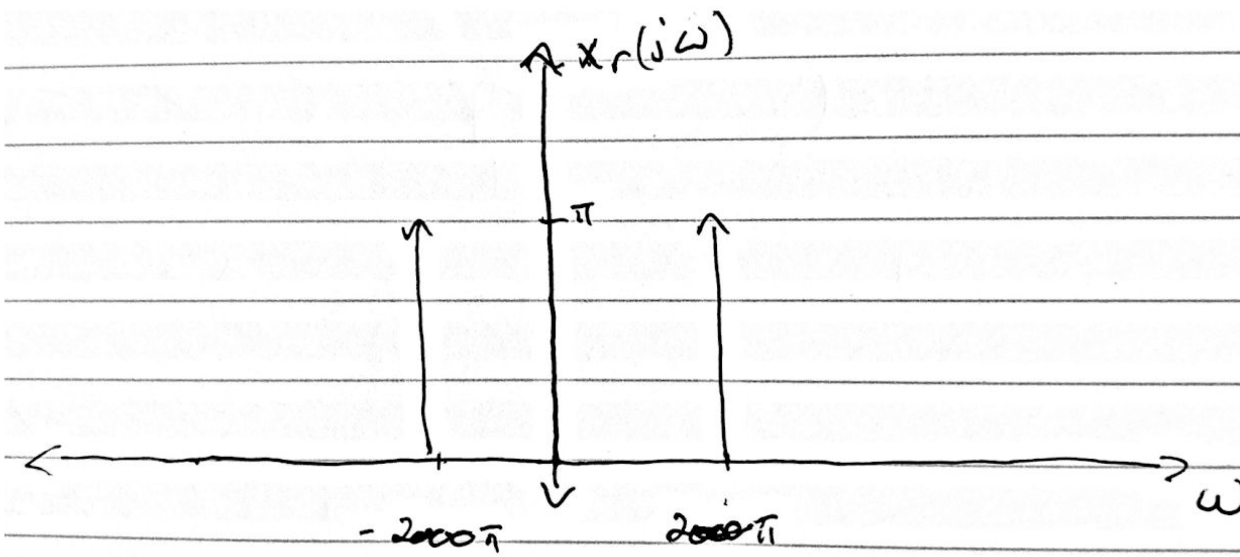
Noah Lutz

2. $x(t) = cos(2\pi 1000t) = cos(2000\pi t)$, $fs = 5000Hz$

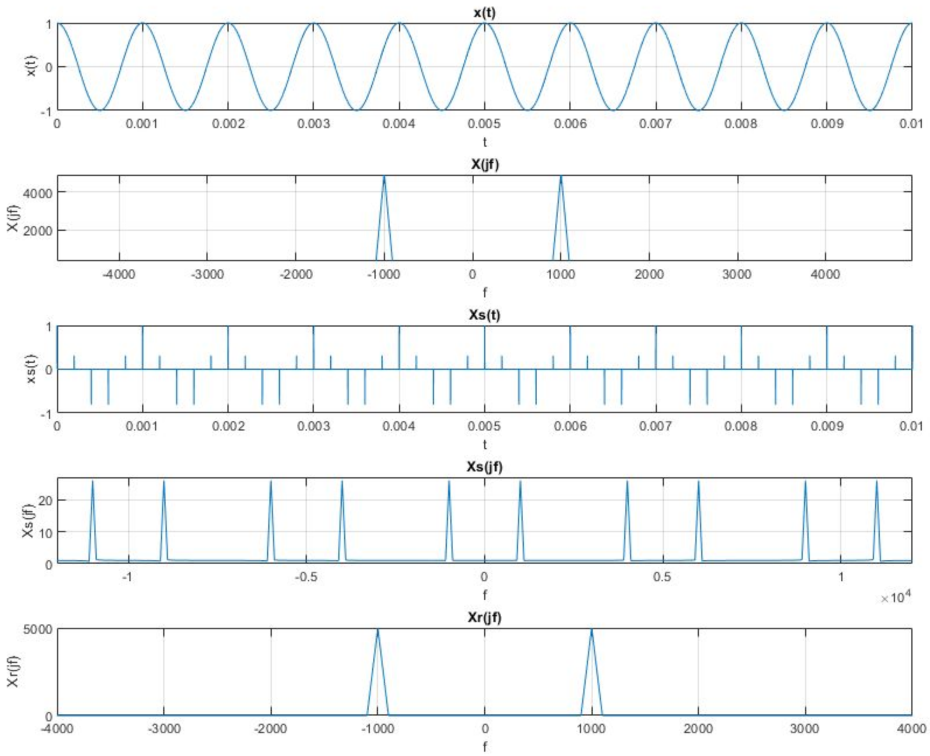
   a. $Xs(j\omega) = \frac{1}{Ts}\sum_{k=-\infty}^{\infty}\pi(\delta(\omega - 2000\pi - k10000\pi) + \delta(\omega + 2000\pi - k10000\pi))$

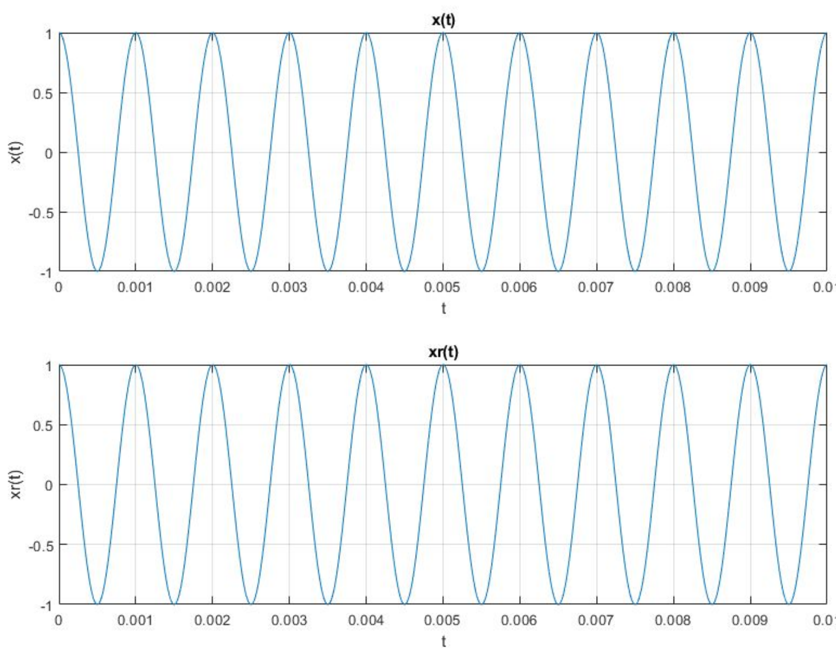


   b. $Xr(j\omega) = Hr(j\omega)Xs(j\omega) = \pi(\delta(\omega - 2000\pi) + \delta(\omega + 2000\pi)$



c.





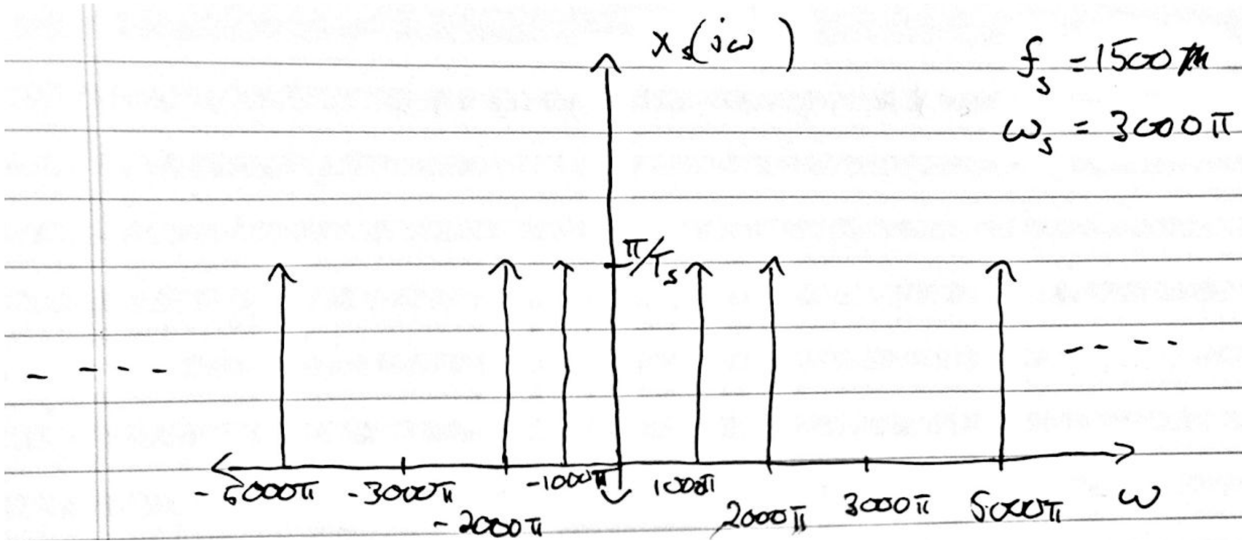
d. The matlab script produced the expected results predicted/sketched in a. and b.

e. No there is no aliasing because the sampling frequency is more than twice the maximum frequency in x(t).

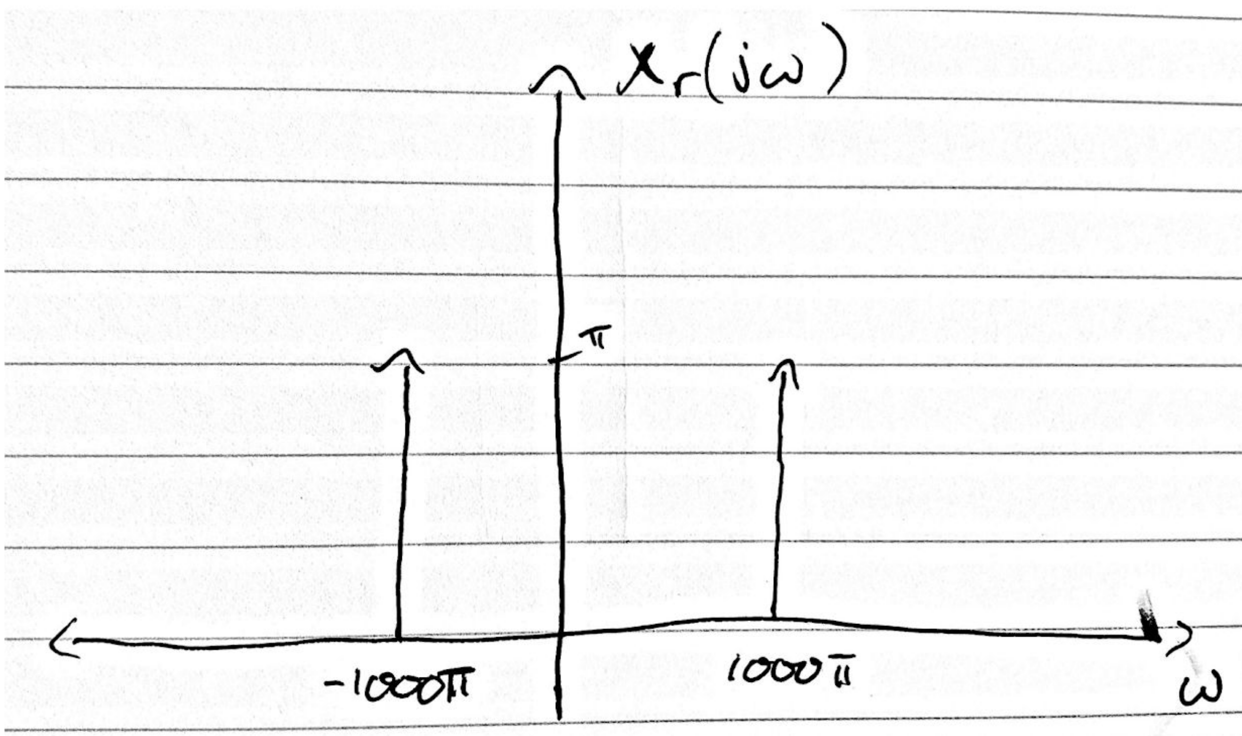
f. The reconstructed signal xr(t) looks identical to the original signal x(t). This is because it was able to be reconstructed without any interference from aliasing.

3. $x(t) = cos(2\pi 1000t) = cos(2000\pi t)$, $fs = 1500Hz$

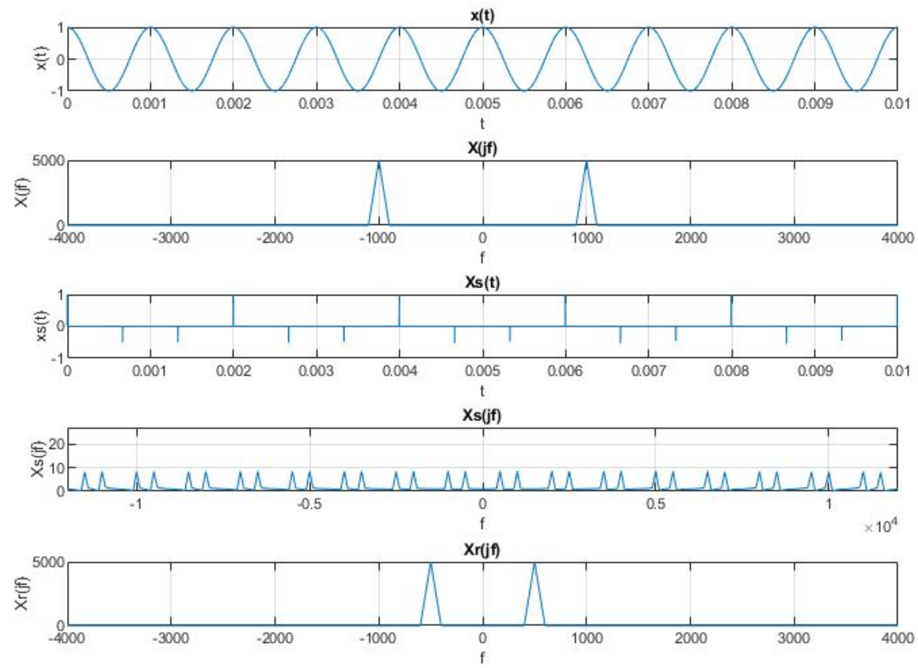
a. $Xs(j\omega) = \frac{1}{Ts} \sum_{k=-\infty}^{\infty} \pi(\delta(\omega - 2000\pi - k3000\pi) + \delta(\omega + 2000\pi - k3000\pi))$

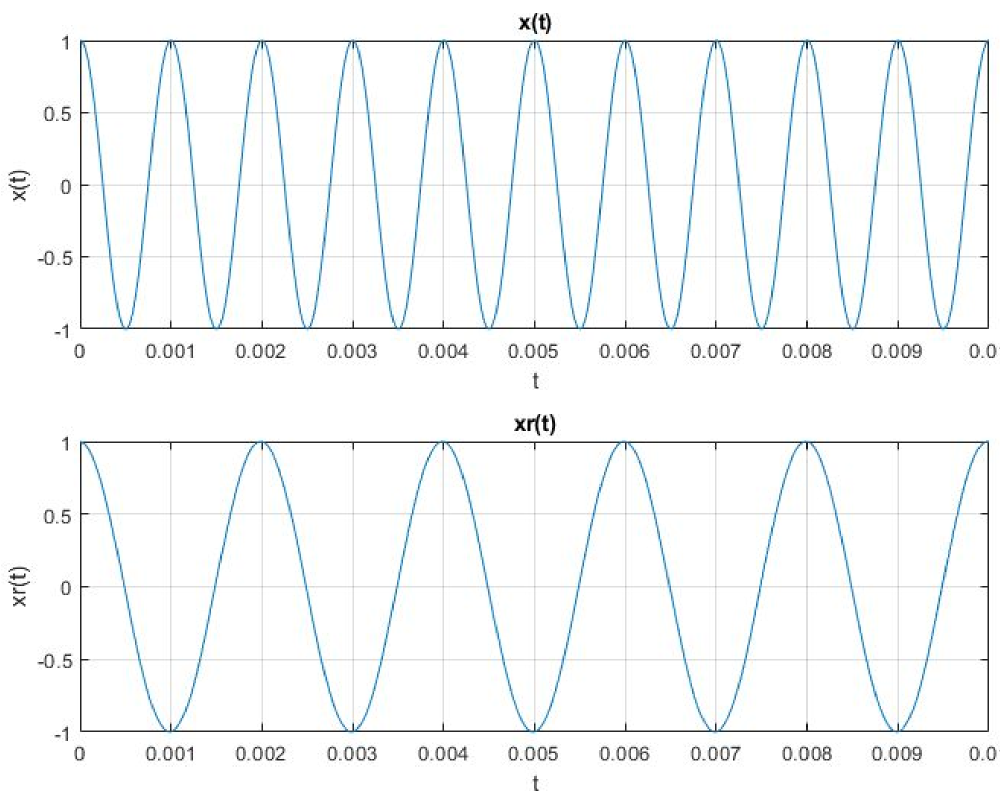


b. $Xr(j\omega) = Hr(j\omega)Xs(j\omega) = \pi(\delta(\omega - 1000\pi) + \delta(\omega + 1000\pi)$



c.

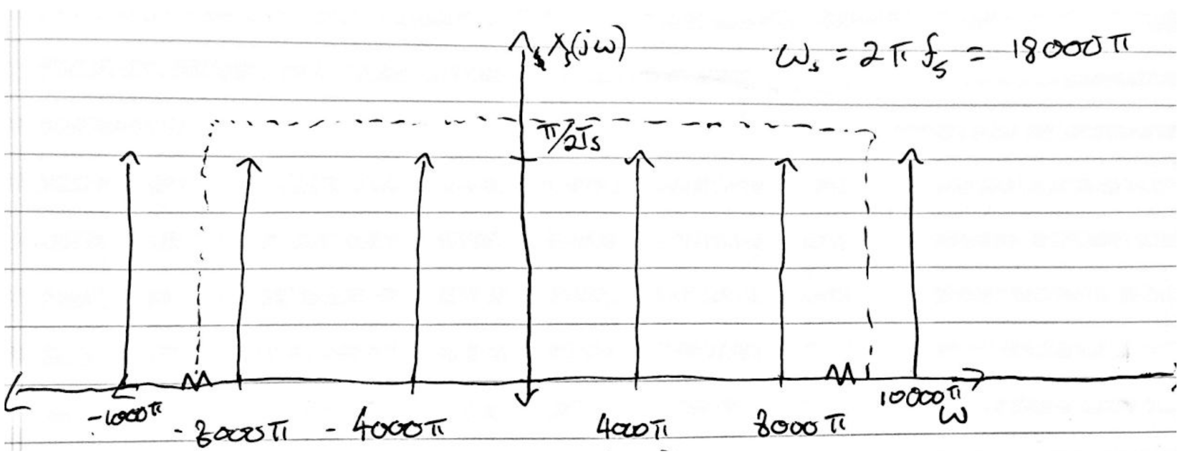




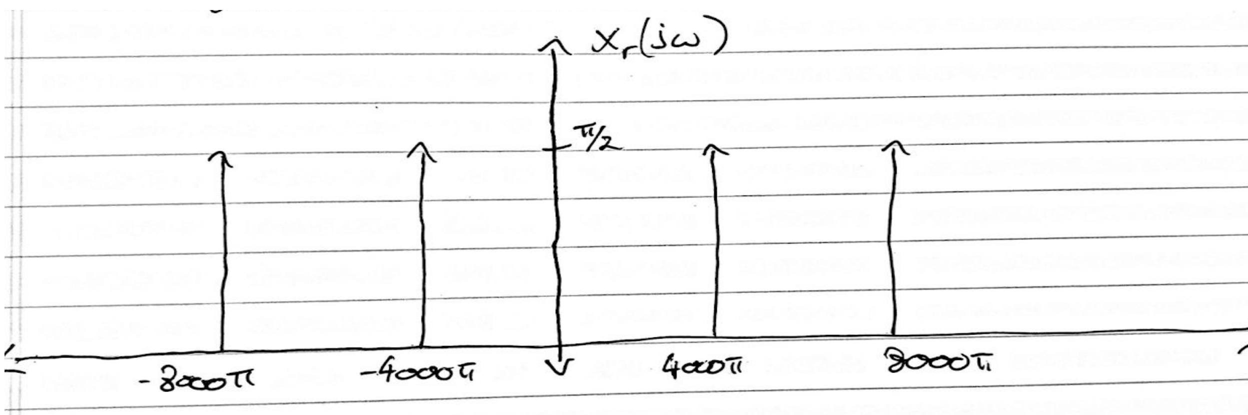
d. The matlab script produced the expected results predicted/sketched in a. and b.
e. Yes there is aliasing because the sampling frequency is less than twice the maximum frequency in x(t).
f. The reconstructed signal xr(t) is not the same as the original sampled signal. Instead is has half the original frequency. This is due to aliasing caused by the sampling frequency being too low.

4. $x(t) = cos(2\pi 1000t)cos(2\pi 3000t) = cos(2000\pi t)cos(6000\pi t)$, $fs = 9000Hz$

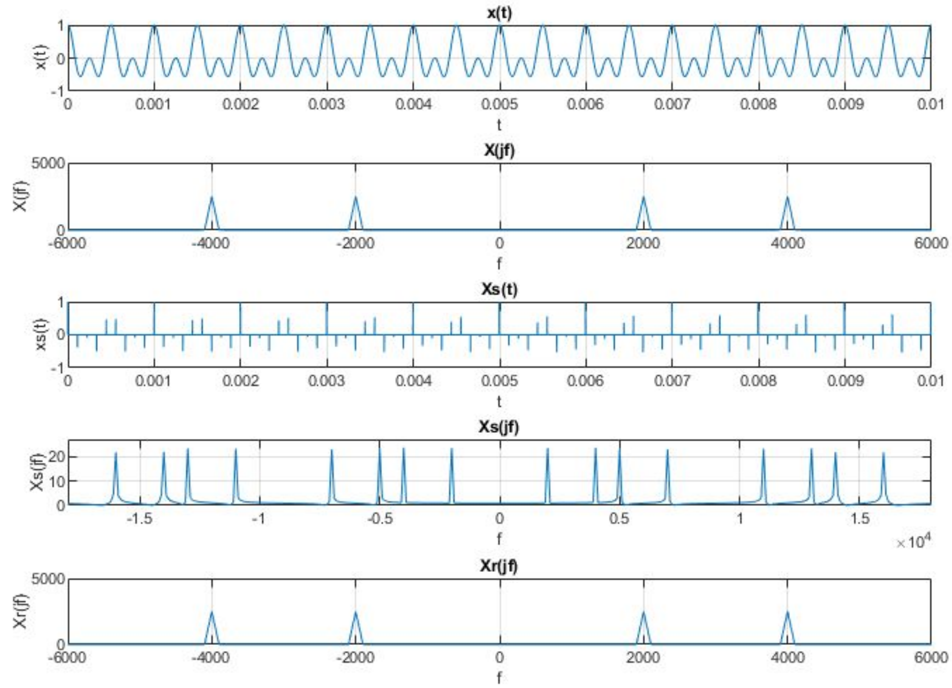
a. $Xs(j\omega) = \frac{1}{Ts}\sum_{k=-\infty}^{\infty} 0.5\pi((\delta(\omega - 2000\pi - 6000\pi - k18000\pi) +$
$\delta(\omega + 2000\pi - 6000\pi - k18000\pi)) + (\delta(\omega - 2000\pi + 6000\pi - k18000\pi) +$
$\delta(\omega + 2000\pi + 6000\pi - k18000\pi)))$

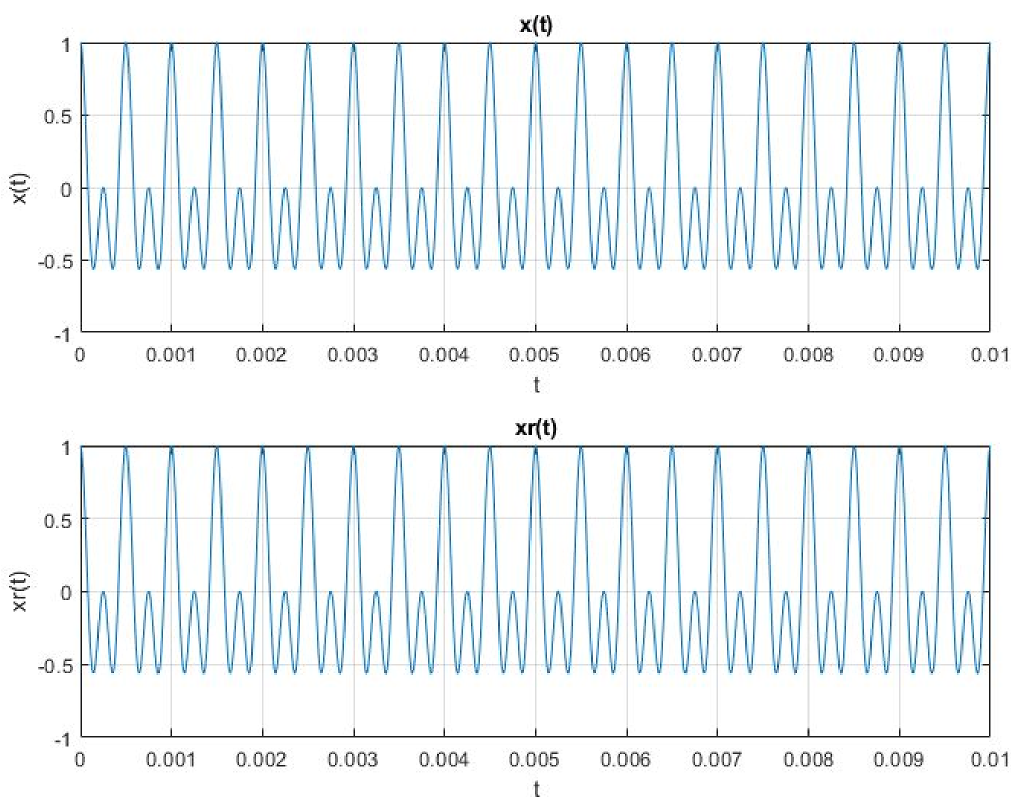


b. $Xr(j\omega) = Hr(j\omega)Xs(j\omega) = 0.5\pi(\delta(\omega - 4000\pi) +$
$\delta(\omega + 4000\pi) + \delta(\omega - 8000\pi) + \delta(\omega + 8000\pi))$



c.





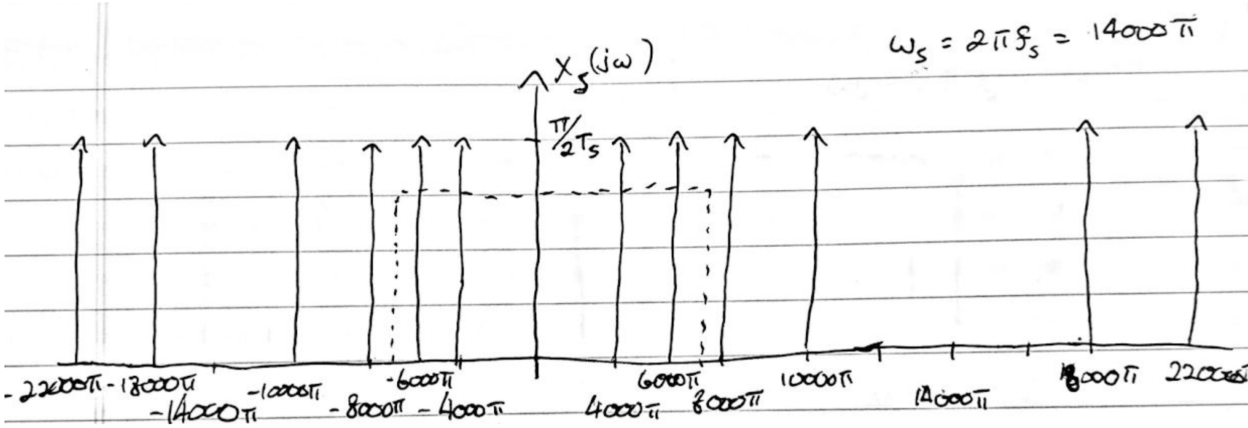
d. The matlab script produced the expected results predicted/sketched in a. and b.

e. No there is no aliasing because the sampling frequency is more than twice the maximum frequency in x(t).

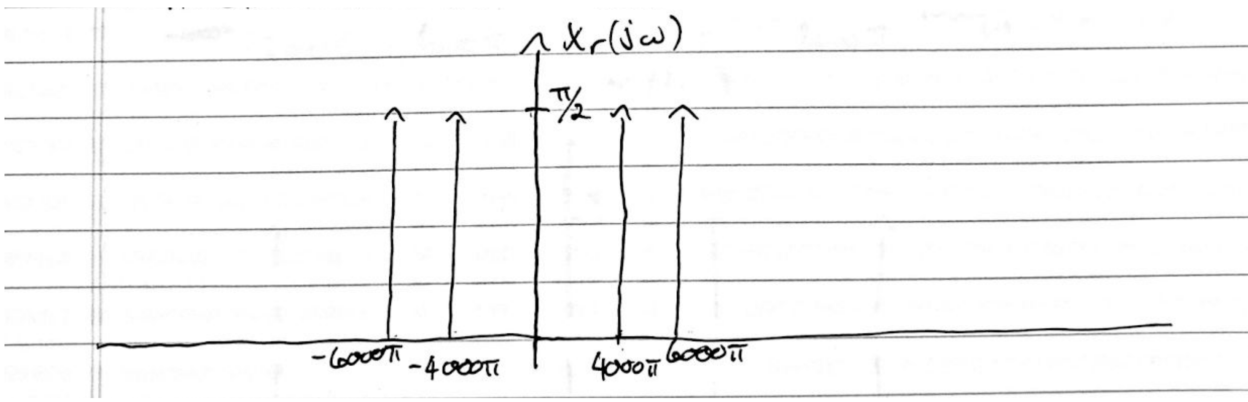
f. The reconstructed signal xr(t) looks identical to the original signal x(t). This is because it was able to be reconstructed without any interference from aliasing.

5. $x(t) = cos(2\pi 1000t)cos(2\pi 3000t) = cos(2000\pi t)cos(6000\pi t)$, $fs = 7000Hz$

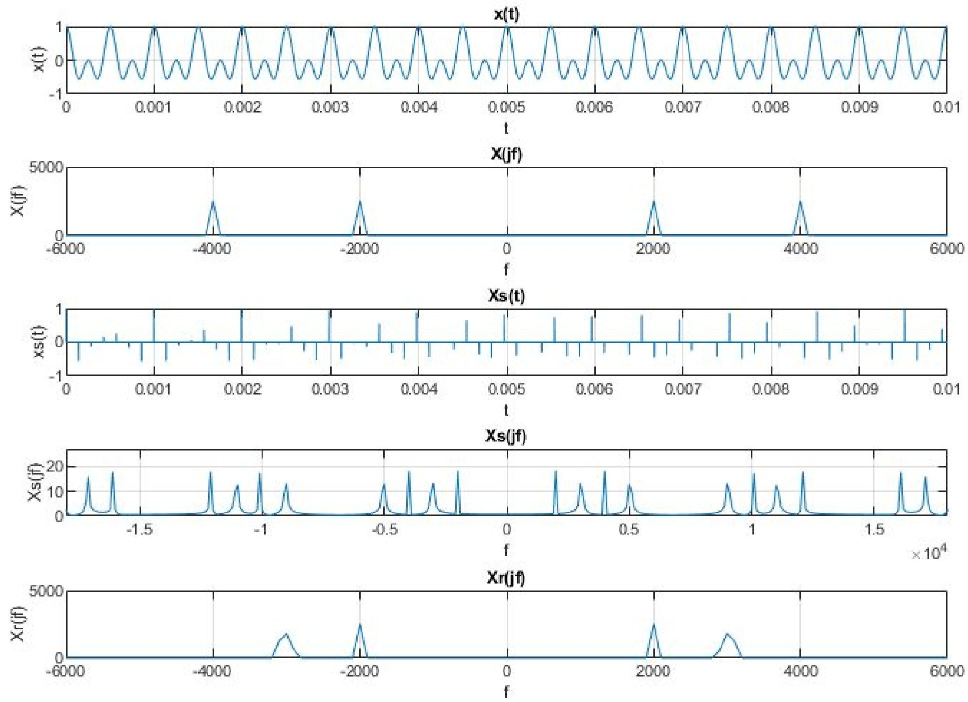
a. $Xs(j\omega) = \frac{1}{Ts}\sum_{k=-\infty}^{\infty} 0.5\pi((\delta(\omega - 2000\pi - 6000\pi - k14000\pi) + \delta(\omega + 2000\pi - 6000\pi - k14000\pi)) + (\delta(\omega - 2000\pi + 6000\pi - k14000\pi) + \delta(\omega + 2000\pi + 6000\pi - k14000\pi)))$

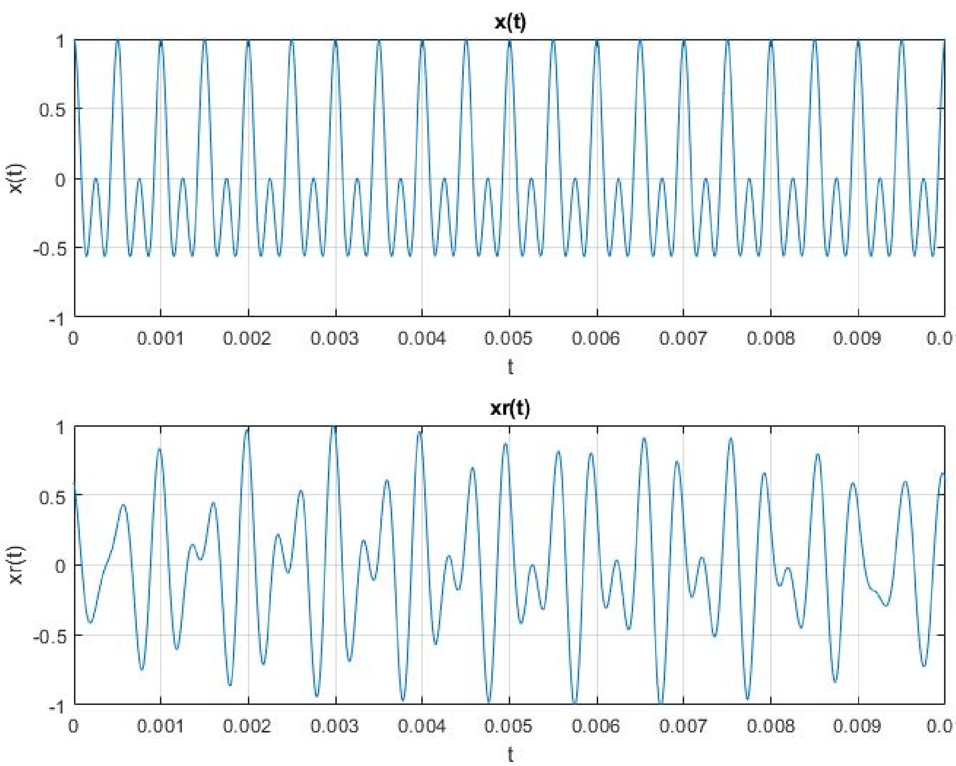


b. $Xr(j\omega) = Hr(j\omega)Xs(j\omega) = 0.5\pi(\delta(\omega - 4000\pi) + \delta(\omega + 4000\pi) + \delta(\omega - 6000\pi) + \delta(\omega + 6000\pi))$



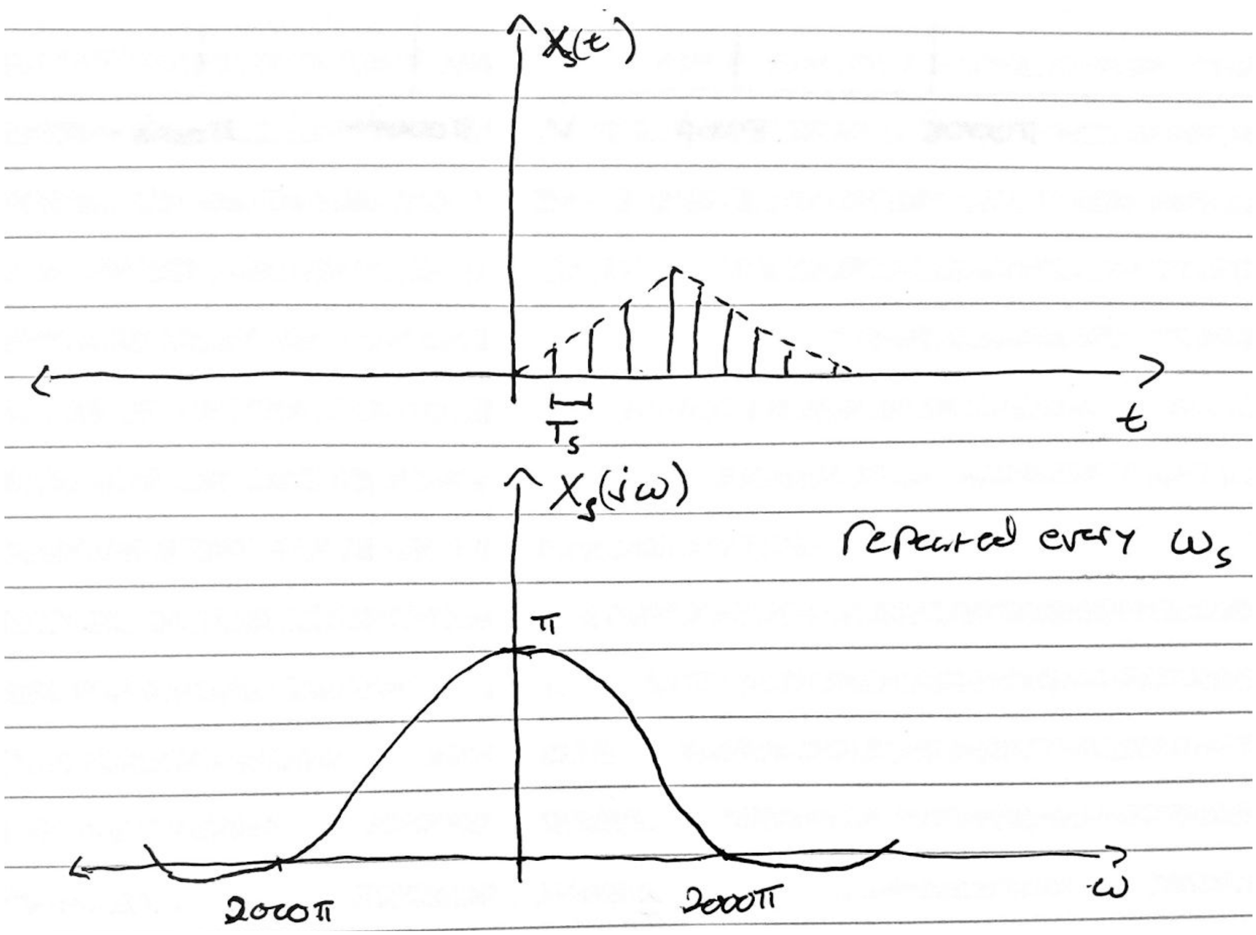
c.


x(t)
x(t)
t
X(jf)
X(jf)
f
Xs(t)
xs(t)
t
Xs(jf)
Xs(jf)
f
$\times 10^4$
Xr(jf)
Xr(jf)
f


x(t)
x(t)
t
xr(t)
xr(t)
t

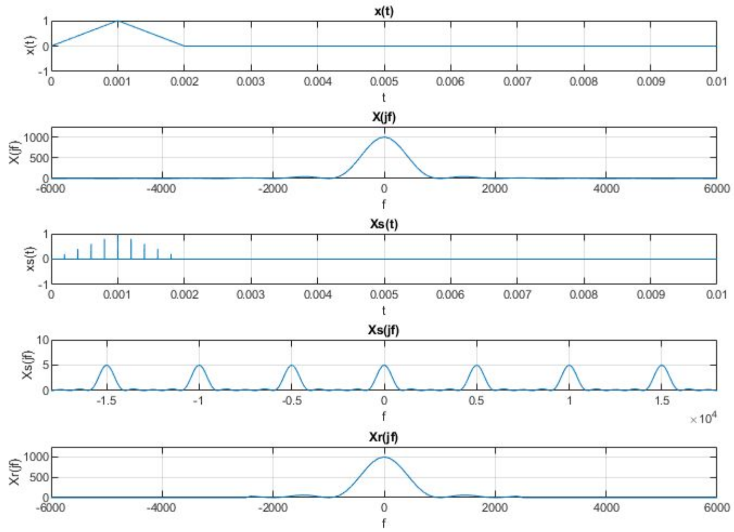
d. The matlab script produced the expected results predicted/sketched in a. and b.
e. Yes there is aliasing because the sampling frequency is less than twice the maximum frequency in x(t).
f. The reconstructed signal xr(t) looks different from the original signal x(t) due to distortion from aliasing.

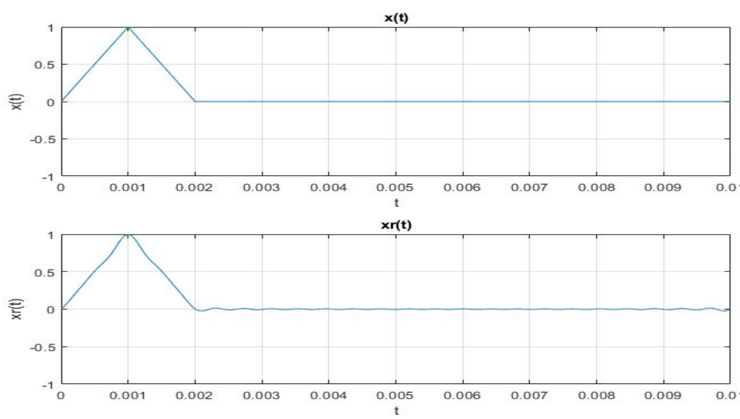
6. If the sampling frequency is low enough, this signal will experience distortion from aliasing. This is due to the fact that when the sampling frequency is low enough, the repeated frequency components in the sampled signal spectrum Xs(jf) will start to interfere with each other in a more significant way, causing the reconstructed signal to become distorted. This frequency seems to be roughly around 1000Hz where the closer to 1000Hz the sampling frequency is, the more distorted the signal becomes. Past this point and the reconstructed signal looks nothing like the input signal at all.



7. $fs = 5000Hz$

a.





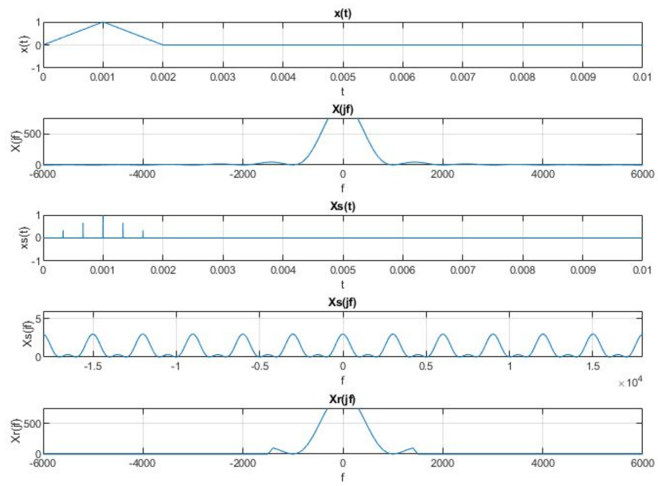
b. The figures produced by matlab follow what was expected/sketched in question 6. The sampled spectrum shows the sinc function repeated every 5000Hz.

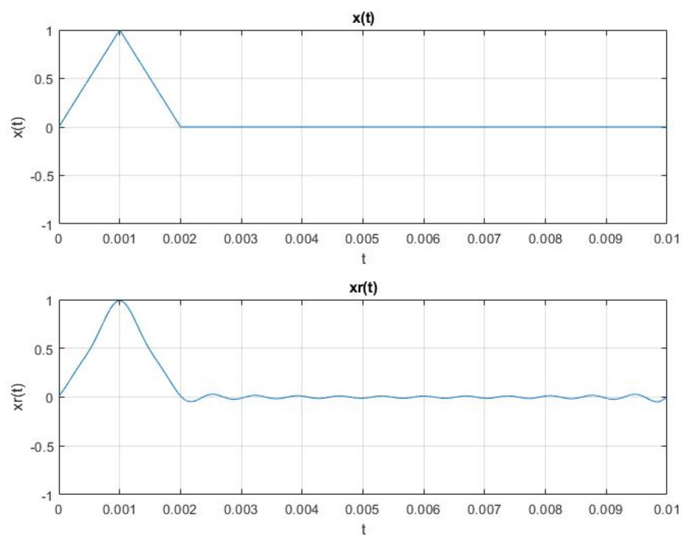
c. There is a very slight amount of aliasing but it is only with the much lower amplitude frequency components so it does not cause a considerable effect on the output signal.

d. The reconstructed signal looks almost identical to the input signal, other than the slightly less sharp edges. This is due to the little to no aliasing from the high enough sampling frequency.

8. $fs = 3000Hz$

a.





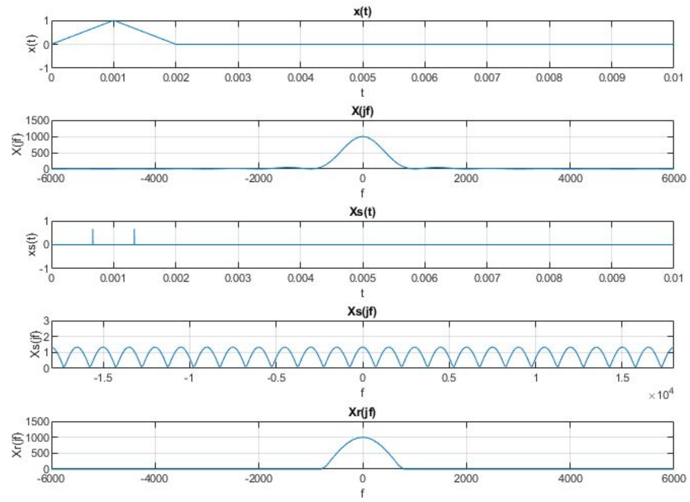
b. The figures produced by matlab follow what was expected/sketched in question 6. The sampled spectrum shows the sinc function repeated every 3000Hz.

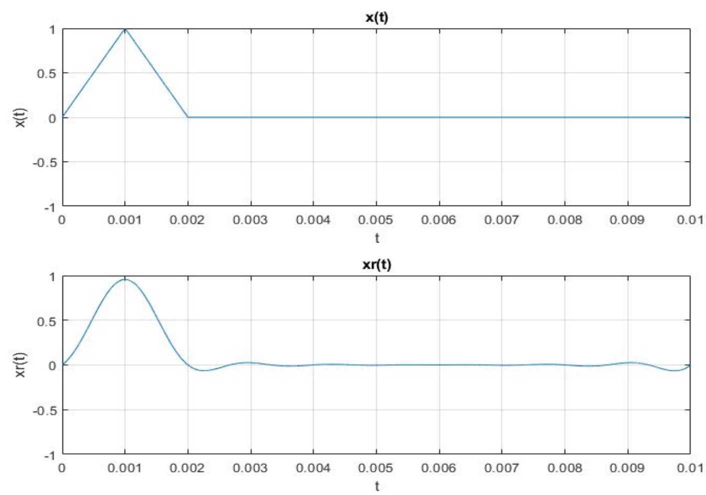
c. There is slightly more aliasing with this signal due to the lower sampling frequency. However, it is still not enough to distort the reconstructed waveform in an unrecognizable way.

d. The reconstructed signal looks almost identical to the input signal. This is due to the little to no aliasing from the high enough sampling frequency. There are slightly more low frequency components to this waveform than the previous one in question 7 but not enough to make the waveform unrecognizable.

9. $fs = 1500Hz$

a.





b. The figures produced by matlab follow what was expected/sketched in question 6. The sampled spectrum shows the sinc function repeated every 1500Hz.

c. There is a considerably high amount of aliasing in this signal than the previous two. This is due to the fact that in the sampled frequency signal has the original signal repeating every 1500Hz, causing more significant aliasing.

d. The reconstructed signal still resembles the input signal, but now, due to aliasing, the signal is much more rounded and has other frequency components quite obvious.