3.1 a) $f_s \geq 2 f_{o\,max}$ $\Rightarrow$ if $f_{max} = 15$ Hz

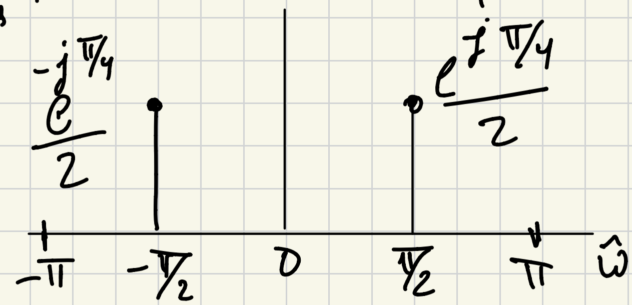
$\Rightarrow f_s \geq 30$ Hz

3.1 B) Signal $x(n) = \cos(2\pi(15)t + \phi)$ $\quad \phi = \pi/4$

$t = \frac{n}{f_s}$ $\quad \hat{\omega} = 2\pi\left(\frac{f_0}{f_s}\right) \Rightarrow 2\pi\left(\frac{15}{20}\right) = \frac{6\pi}{4}$

Reduce $\hat{\omega}$ s.t. $-\pi \leq \hat{\omega} \leq \pi$ $\Rightarrow \hat{\omega} = \frac{\pi}{2}$

$x[n] = \cos\left(\frac{\pi}{2}n + \pi/4\right)$



3.1 c) $A = 1$

$\Rightarrow$ Complex amplitude is $\frac{1}{2}e^{j\pi/4}$

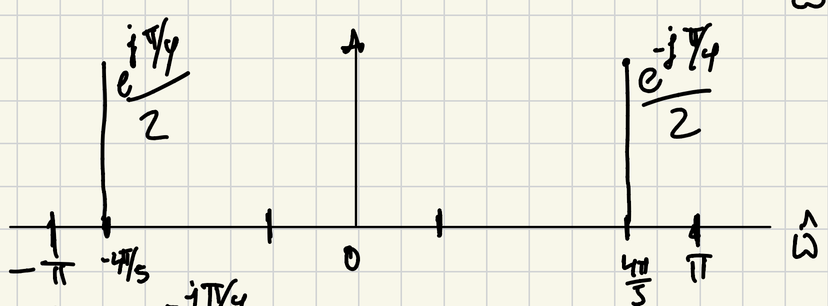
3.1 D) $f_0 = 12$ Hz $\quad f_s = 20$ Hz $\quad \phi = \pi/4$

$\cos(-\frac{4\pi}{5}n + \pi/4) = \cos(\frac{4\pi}{5} - \pi/4)$

$\hat{\omega} = \frac{12}{20}(2\pi) - 2\pi l$

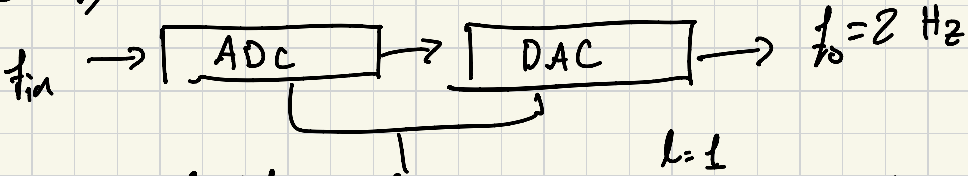
$= \frac{3}{5}(2\pi) - 2\pi l$

$= \frac{6\pi}{5} - 2\pi l \Rightarrow -\frac{4\pi}{5}$, $l = 1$



3.1 E) $\frac{e^{-j\pi/4}}{2}$

3.1 f)



$$f_{in} = \begin{cases} f_0 + l f_s \\ -f_0 + l f_s \end{cases}$$

$l = 1$

$f_{in} = 22$ Hz $\quad \phi = -3\pi/4$

$f_{in} = 18$ Hz $\quad \phi = 3\pi/4$

$l = 2$ $\quad f_{in} = 42$ Hz $\quad \phi = -3\pi/4$

3.1 f) $f_{in} = 15$ Hz $\quad \phi = \pi/4$

$-\pi < \hat{\omega} < 0 \Rightarrow \hat{\omega} = 2\pi\left(\frac{15}{f_s}\right) - 2\pi l$

$-\cancel{\pi} < \hat{\omega} = \cancel{2\pi}\left(\frac{15}{\frac{4}{f_s}} - l\right) < 0$

$f_s = 19$ Hz

$\frac{15}{20} = \frac{3}{4}(2\pi) = \frac{6}{4}\pi - 2\pi l = \frac{-2\pi}{4} = \frac{-\pi}{2} \Rightarrow$

$\frac{15}{18} \quad \frac{5}{6}(2\pi) \quad \frac{10}{6}\pi - 2\pi l \qquad -10\pi \quad 2\pi(-5)$

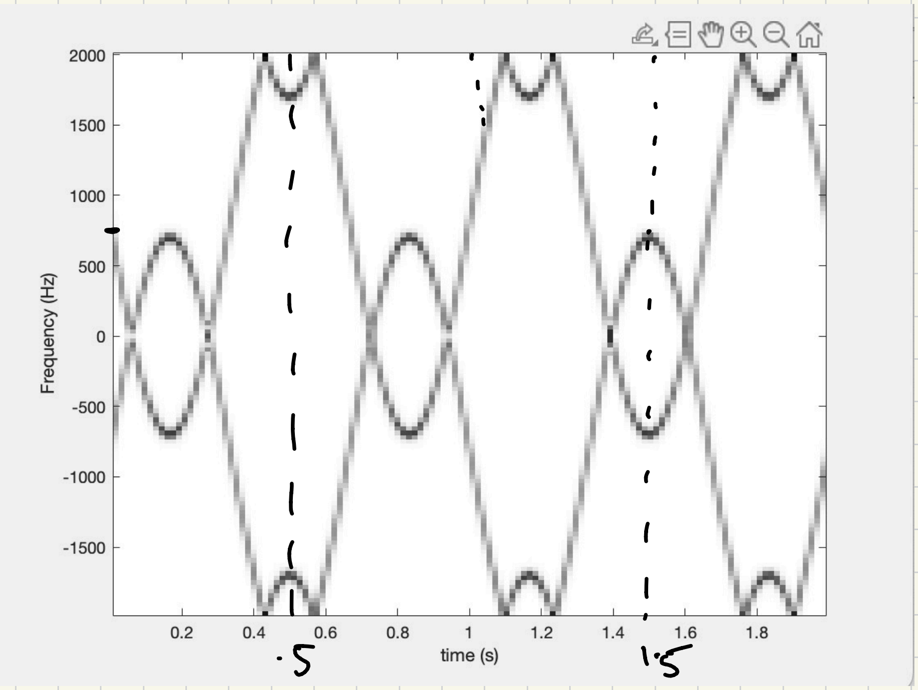
$\frac{-2\pi}{6} = \frac{-\pi}{3}\ (18)\ t = -6\pi \quad 2\pi(-3)$

$\frac{15}{19}\cdot(2\pi) \quad \frac{30}{19}\pi - 2\pi l$

$-\frac{8\pi}{\cancel{19}}\cancel{(19)}$

3.2 a) $x(t) = A\cos(2\pi f_c t + \alpha\cos(2\pi\beta t + \gamma))$

$A = 2$, $f_c = 800$ Hz, $\alpha = 1000$ Hz, $\beta = 1.5$, $\gamma = 0$, $f_s = 4000$

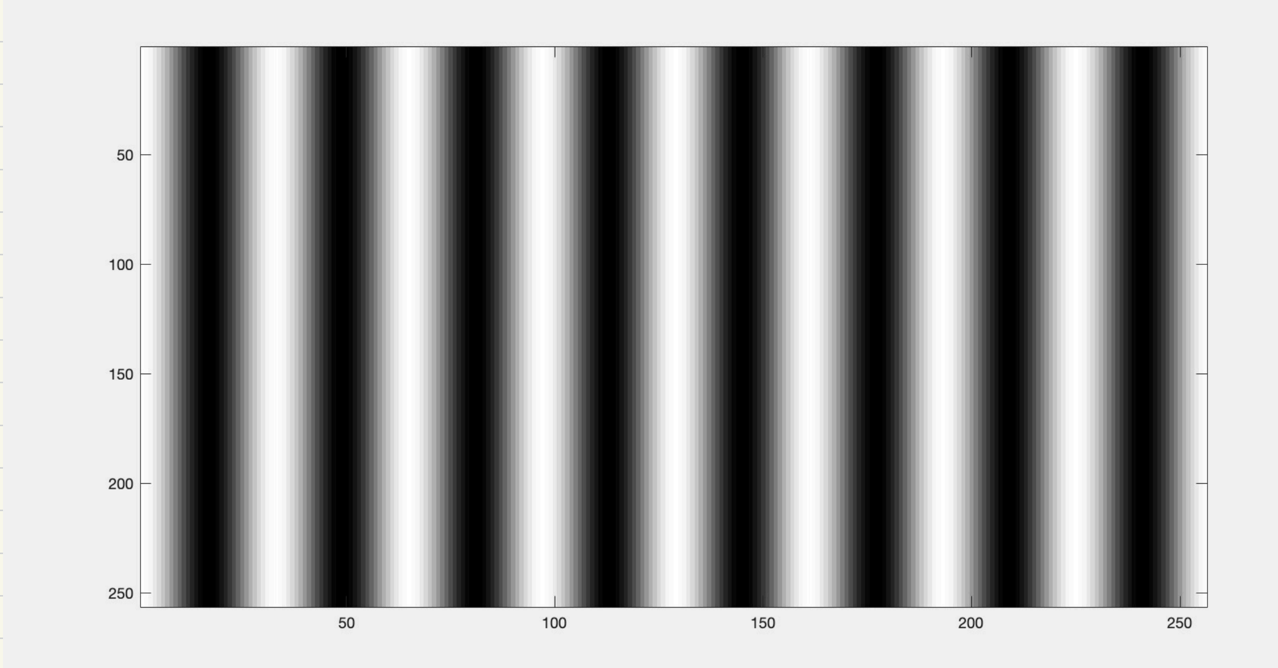


f_i is correct within the Range $|0 \,\&\, 2000$ Hz$|$ Given that the f_i is

$\frac{d\psi(t)}{dt}\frac{1}{2\pi} = f_c + -\alpha(\beta)\sin(2\pi\beta t)$

800 is lifted by max 1500 which would pass 2000 Hz and alias the signal as f_s is 4000.

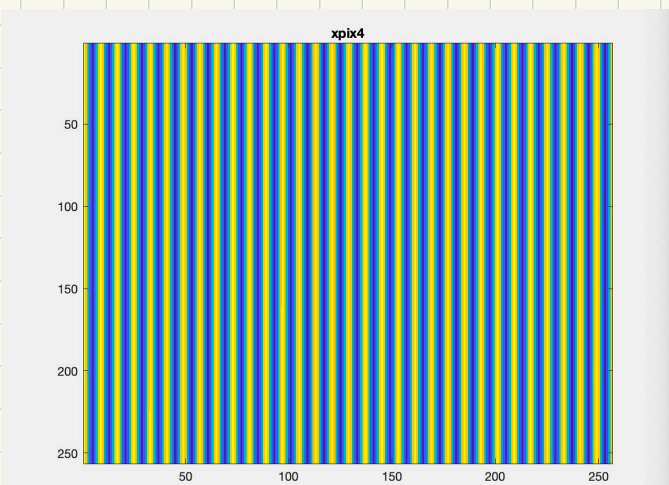
3.3 a)

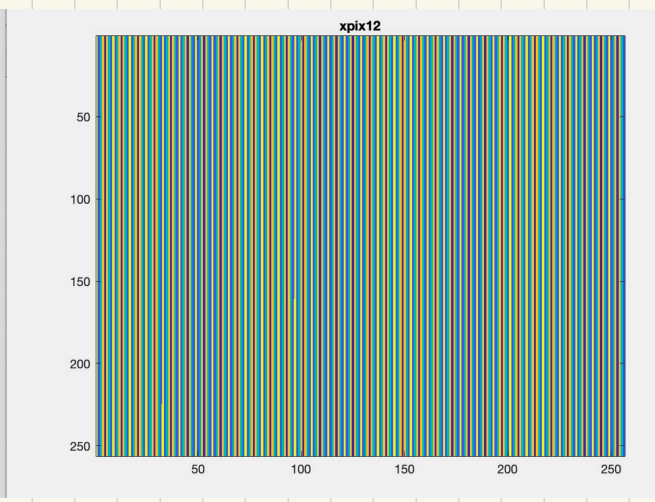


3.3 B)

Black is -1 while white is 1

3.4 a)

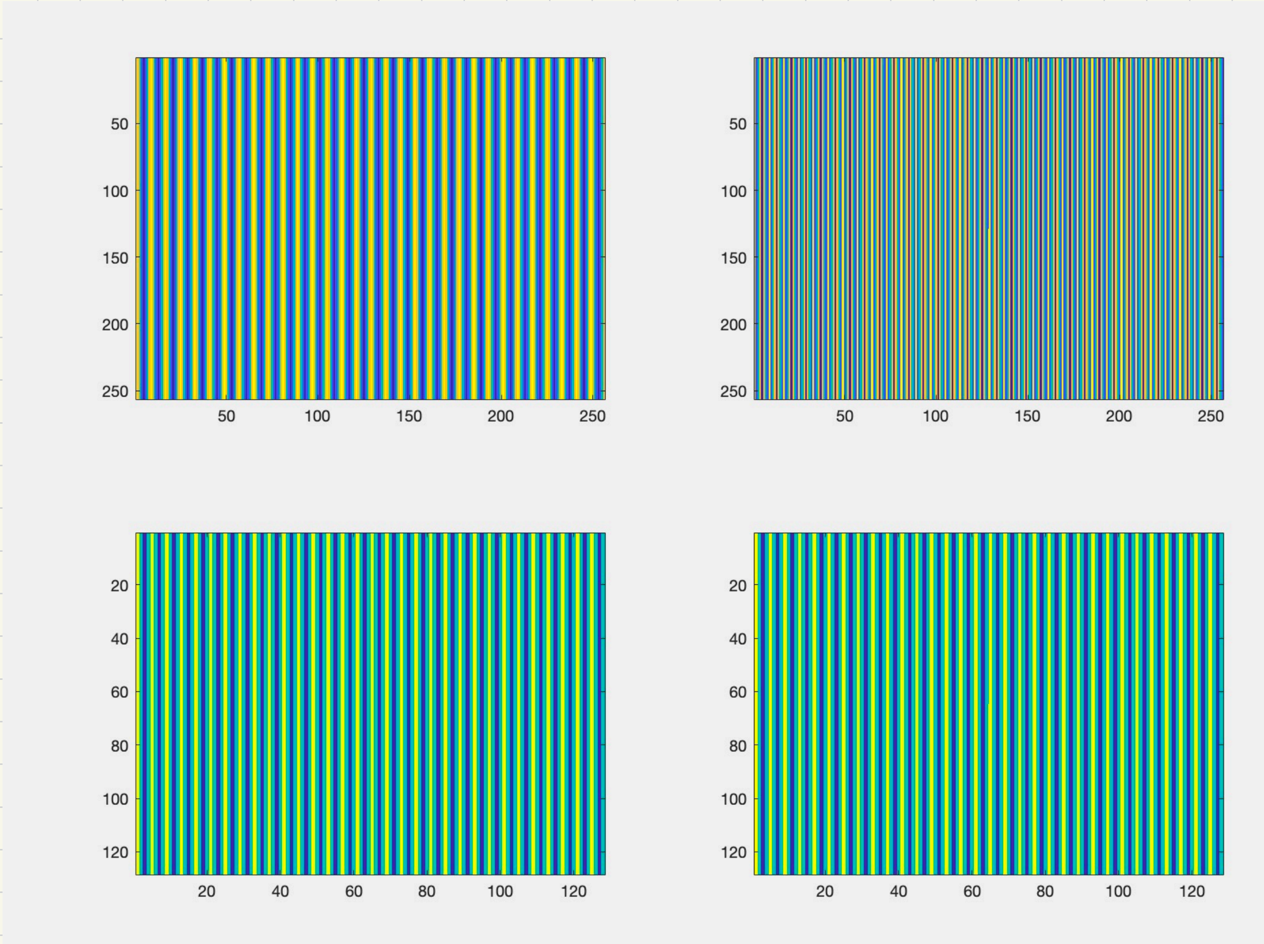




- xpix 12 is higher frequency Cause Because the cosine function oscillates between -1 and 1 3 times as fast as xpix 4
  ⇒ shorter horizontal period

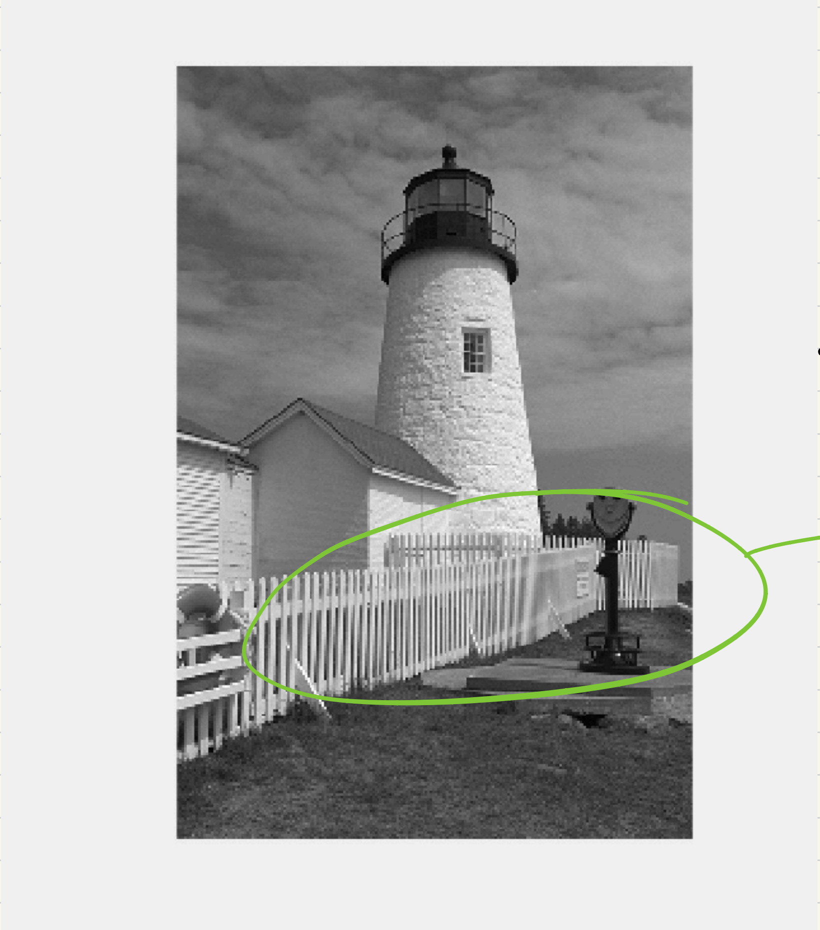
3.4 B) Next page

3.4 B)



every other sample(s) is removed and essentially the sampling rate is halved. Considering now the first signal was $\hat{\omega} = 2\pi\left(\frac{4}{32}\right)$ and the second $\hat{\omega} = 2\pi\left(\frac{12}{32}\right)$. If we half the f_s to be 16 $\Rightarrow \hat{\omega}_4 = 2\pi\left(\frac{4}{16}\right) = \frac{\pi}{2}$ and $\hat{\omega}_{12} = 2\pi\left(\frac{12}{16}\right) = 2\pi\left(\frac{3}{4}\right) = \frac{6\pi}{4} - 2\pi l = -\frac{2\pi}{4} = -\pi/2$ a signal of same <u>aliased</u> frequency.

3-5 A) Down Sampled Size is 312 x 214



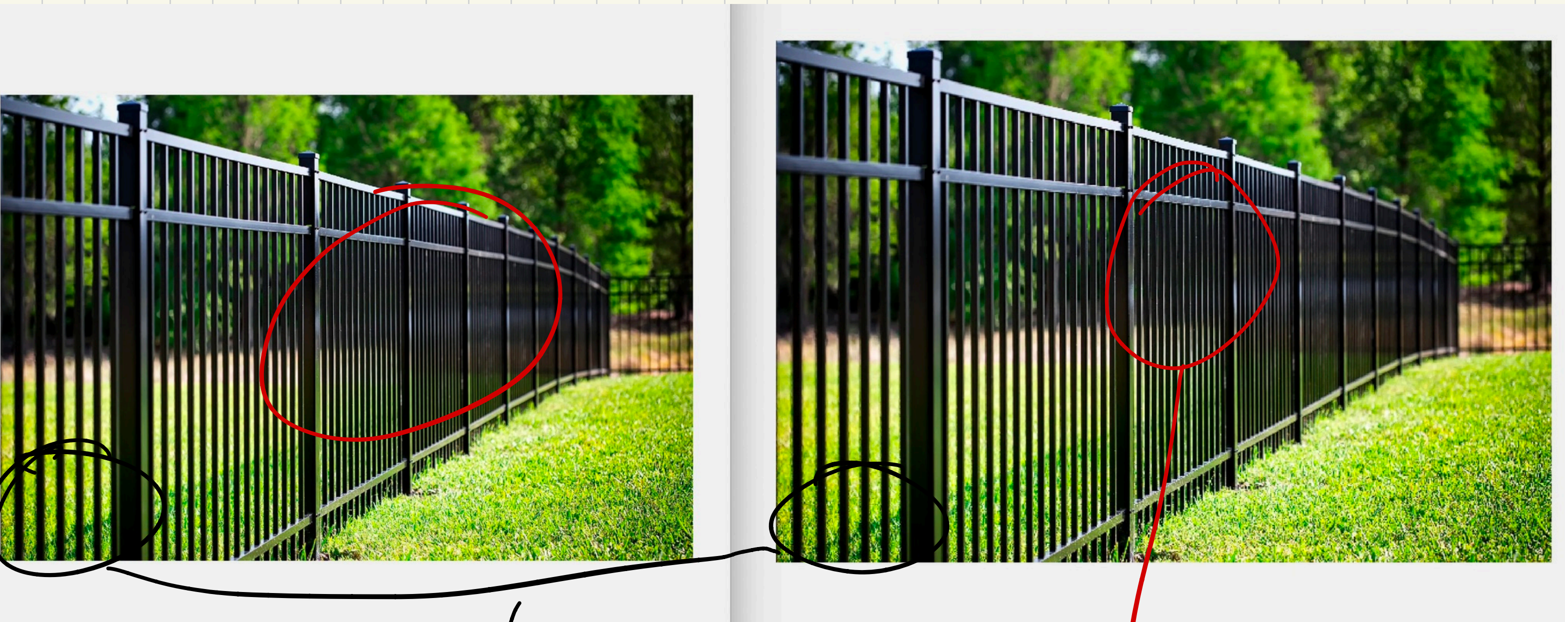
3-5B)

most significant effects of aliasing

it appears Blurry and almost skips Details

The Small fence holes/planks are increasing in frequency at that Region and the Down Sampled image cannot Reconstruct it well.

Own Image



Other regions of the fence (closer to us) is not aliased as the horizontal frequency of Green -> Black is very low so even w/ a factor of 3 down sampled => image is not aliased in that region.

in here you can see faint shapes in the rails of the fence => skips the non black regions when down sampling by a factor of 3.