Solution using tclSADIE processing:

1. Apply a blur and noise reduction Wiener filter to “SMPTEdegraded.ipt.” The blur impulse response $h(m,n)$ is:

\[
\begin{array}{ccc}
1 & 2 & 1 \\
2 & 4 & 2 \\
1 & 2 & 1 \\
\end{array}
\]

You may want to constrain the amplitude inverse filter to avoid excessive high frequency boosting or division by zero (notes p380). Use a cascade Wiener filter (notes p393) with an adaptive noise reduction component (notes p387). (80%)

3x3 LP of noisy image $g(m,n)$
3x3 HP of noisy image \( g(m,n) \)

Estimate noise variance:

select region within a uniform square and calculate statistics:

\[
\begin{align*}
\text{min} &= 173 \\
\text{max} &= 233 \\
\text{mean} &= 204.03 \\
\text{stdev} &= 9.1797 \\
\text{var} &= 84.27
\end{align*}
\]

Estimate noiseless signal variance:

calculate local noisy image variance
subtract global noise variance at each pixel
if result less than zero, clip at zero (maintain positive weight on HP component)
local noisy image variance - noise variance = $\sigma_f^2(m,n)$:

adaptive WF factor $\frac{\sigma_f^2(m,n)}{\sigma_f^2(m,n) + \sigma_v^2}$
adaptive noise WF result

Must pad the 3x3 PSF to match the 512x512 size of the image in order to do inverse filtering. padded PSF (centered at (257,257) in tclSADIE; centered at (1,1) in MatLab)
Take Fourier transform to get $H(k,l)$ and then inverse $|H(k,l)|^{-1}$. Note, phase of $H$ should be zero, consistent with symmetric $h$.

$|H(k,l)|^{-1}$ clipped at maximum boost of 10

raw restored result (IFc10); min-max DN scaling in tclSADIE
Inverse filter restoration causes DNs in restored image to exceed range of original DNs. Contrast is reduced in tclSADIE display because of increased DN range. Therefore, must clip results to gain full benefit of restoration. Clip DNs at 0 and 255.

Final restored image \( \text{IFc} \leq 10 \)

Try lower boost on IFc. Clip at 2.
raw restored result ($\text{IFc} \leq 2$)

Final restored image $\text{IFc} \leq 2$
2. Use the measure of performance you developed for HW3 (or define a new one), and compare the performance of the above Wiener filter to a 3x3 convolution HBF with K=1, 2 and 3 (notes p171). (20%)

Answer will depend on your performance metric, but should show that the above adaptive WF-IFc results in higher SNR than does a simple HBF, which simultaneously amplifies signal and noise.