

10.1 (b)

| Window      | Ratio of Main lobe<br>to side lobe |        |        | Width of<br>main lobe |        |        |
|-------------|------------------------------------|--------|--------|-----------------------|--------|--------|
|             | $N=51$                             | $N=71$ | $N=91$ | $N=51$                | $N=71$ | $N=91$ |
| Rectangular | -12dB                              | -10dB  | -5dB   | 0.24                  | 0.18   | 0.11   |
| Bartlett    | -28dB                              | -20dB  | -21dB  | 0.5                   | 0.4    | 0.2    |
| Hamming     | -40dB                              | -38dB  | -36dB  | 0.5                   | 0.3    | 0.2    |
| Hanning     | -20dB                              | -25dB  | -20dB  | 0.48                  | 0.3    | 0.18   |
| Blackman    | -50dB                              | -60dB  | -50dB  | 0.9                   | 0.45   | 0.3    |

d) As  $N$  increases, width of lobes decreases,  
Difference between peak and side lobes  
is more visible

Although Difference between Peak and side  
lobes don't change too much

10.2 a) Yes, because fftshift brings frequency at 0 in centre. and if we want symmetric signal  $\frac{N-1}{2}$  should be some integer. Also for linear phase  $\frac{N-1}{2}$  should be integer.  $\Rightarrow N$  is odd.

For linear phase, symmetry,  $N$  is odd & causal

b) Windows are to be symmetric so that impulse response is symmetric, so that final output is linear phase and symmetric. To get linear phase, windows are symmetric in FIR filter. and also for causality.

c) Yes

d) Kaiser or Blackman is preferred window as their side lobes are -57, -58 dB below peak which is too distinguishable and thus provide more accurate filters