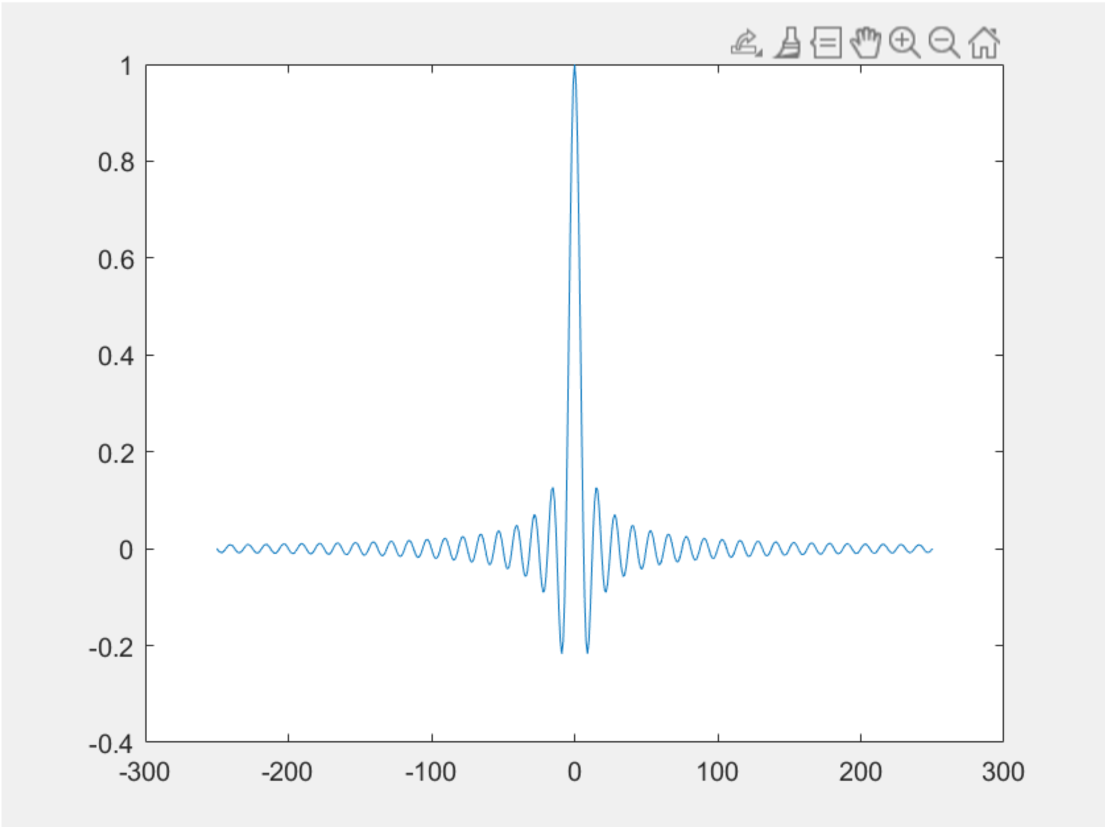
1. Let $x(t)$ be a sinc function written as

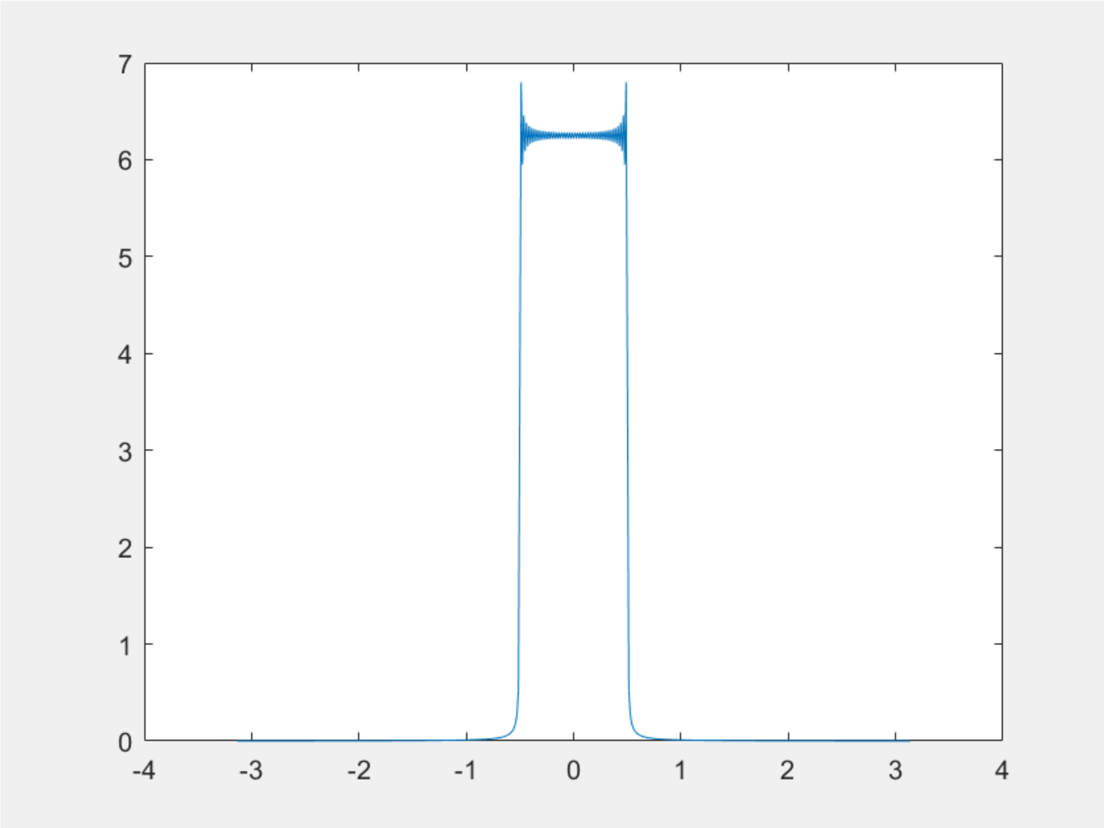
$$x(t) = \frac{\sin(2\pi t)}{2\pi t}$$

Now, $x(t)$ is sampled at a rate $T_s = T / N_1$ so that $x[n] = x(nT_s)$, $n \in \{-N_1, -N_1+1, \ldots 0, \ldots N_1-1, N_1\}$ and N=2N_1+1. Let N=501 and T=20.

(a) (10%) Use the MATLAB function **plot** to plot $x[n]$ vs n.

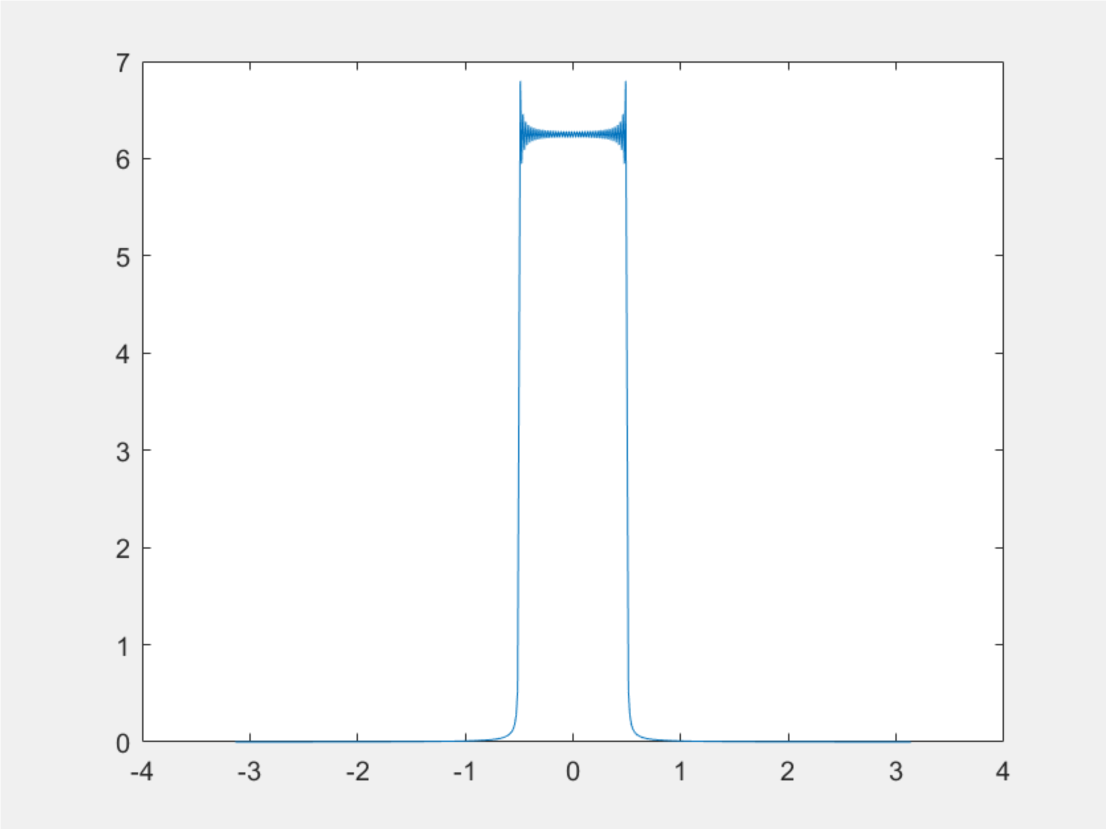


(b) (20%) Use the MATLAB function **fft** directly to compute DFT of $x[n]$, and use the MATLAB function **plot** to plot the magnitude of the **fft** output vs frequency ω. The zero frequency should be centered in your plot. Observe the *Gibbs phenomenon* in (b) and give some explanation for it in your report.



由於 x[n] 的取值為有限範圍，在頻率軸上對應到有限個正弦函數疊加的情形之下，會造成在不連續點附近失真較為嚴重，亦即 Gibbs phenomenon .

(c) (20%) Create a MATLAB program by yourself to compute $X_k(e^{j\omega})$ of equation (1) and use the MATLAB function **plot** to plot the magnitude of $X_k(e^{j\omega})$ vs frequency ω. You also need to rearrange $X_k(e^{j\omega})$ so that the zero frequency is centered in your plot. You should verify whether the answer is the same as question (b).



The answer is the same as question (b) .

2. A way of mitigating *Gibbs phenomenon* is to multiply $x(t)$ by a finite-duration signal $w(t)$, i.e., $y(t) = x(t)w(t)$. The signal $w(t)$ is called as the window function. A famous one is *Hanning* window, which is specifically written as

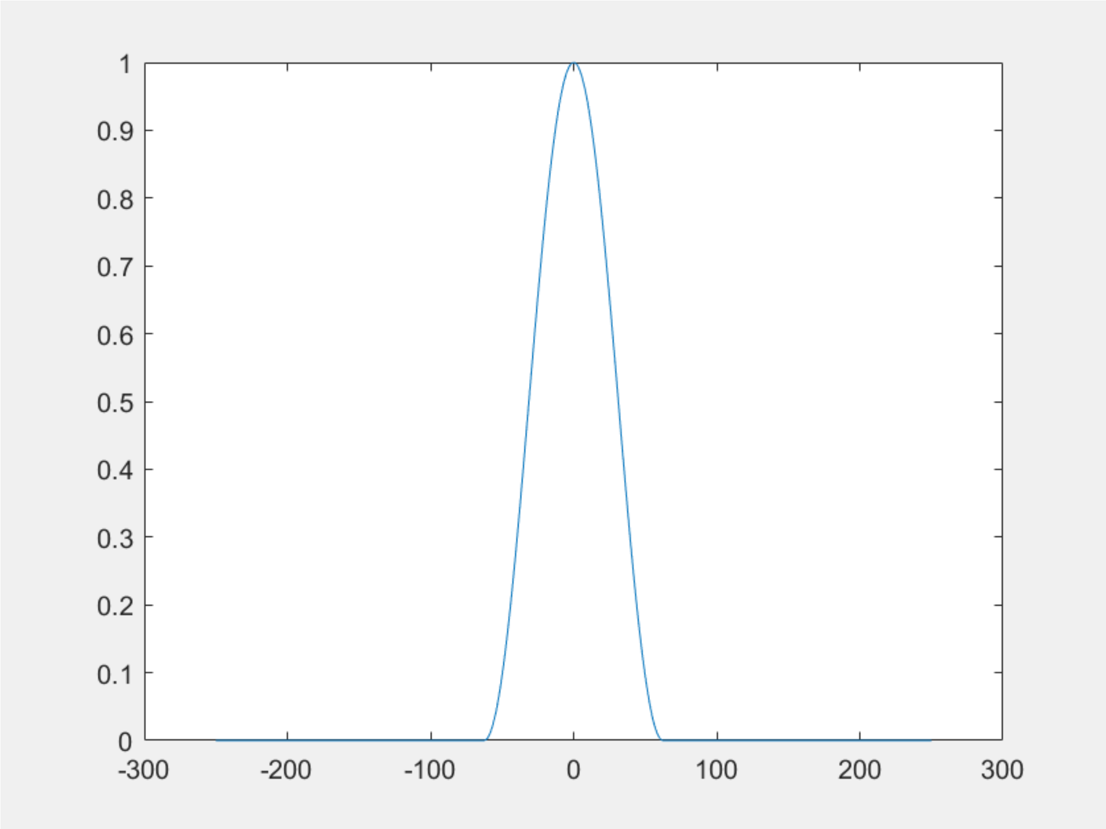
$$w(t) = \begin{cases} \frac{1}{2}[1+\cos(\frac{2\pi|t|}{T_w})], |t| \le T_w/2 \\ 0 \qquad ,\text{else} \end{cases}$$

where T_w denotes the duration of the window function.

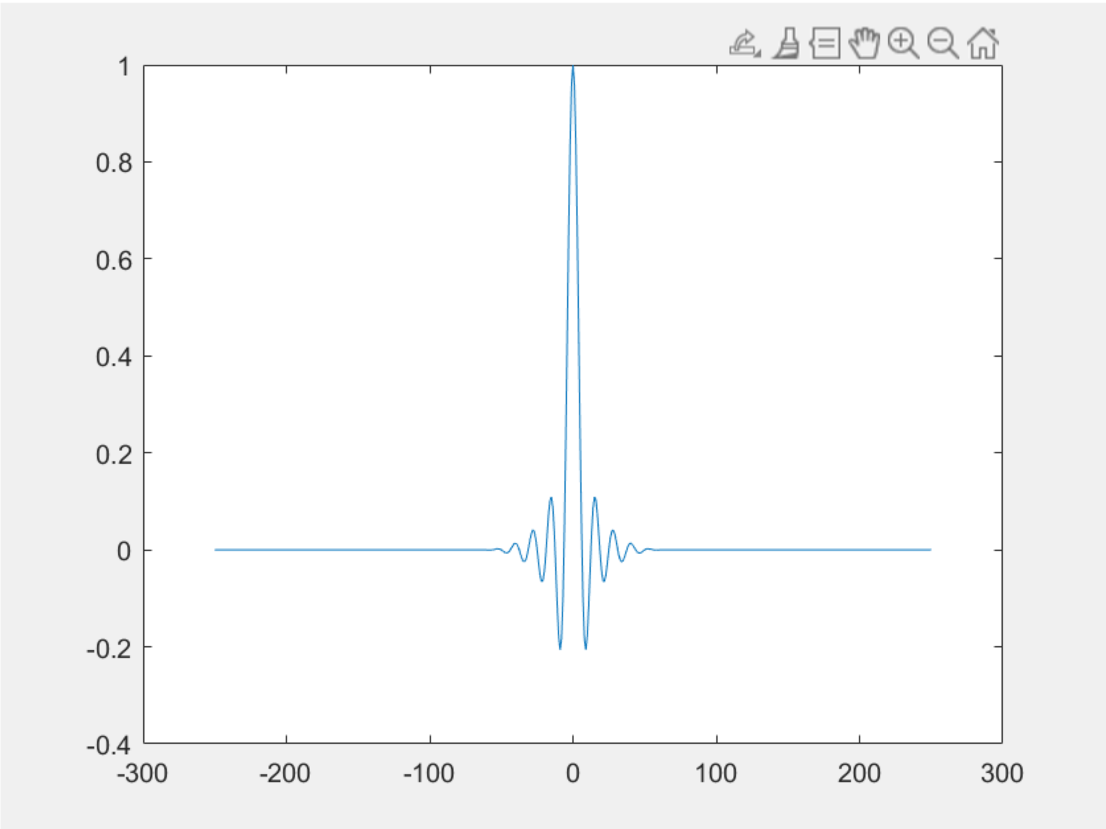
Suppose $w(t)$ is also sampled at a rate $T_s = T/N_1$ so that $w[n] = w(nT_s)$,

$n \in \{-N_1, -N_1+1, \ldots 0, \ldots N_1-1, N_1\}$, N=2N_1+1, N=501, T=20, and T_w=T/2.

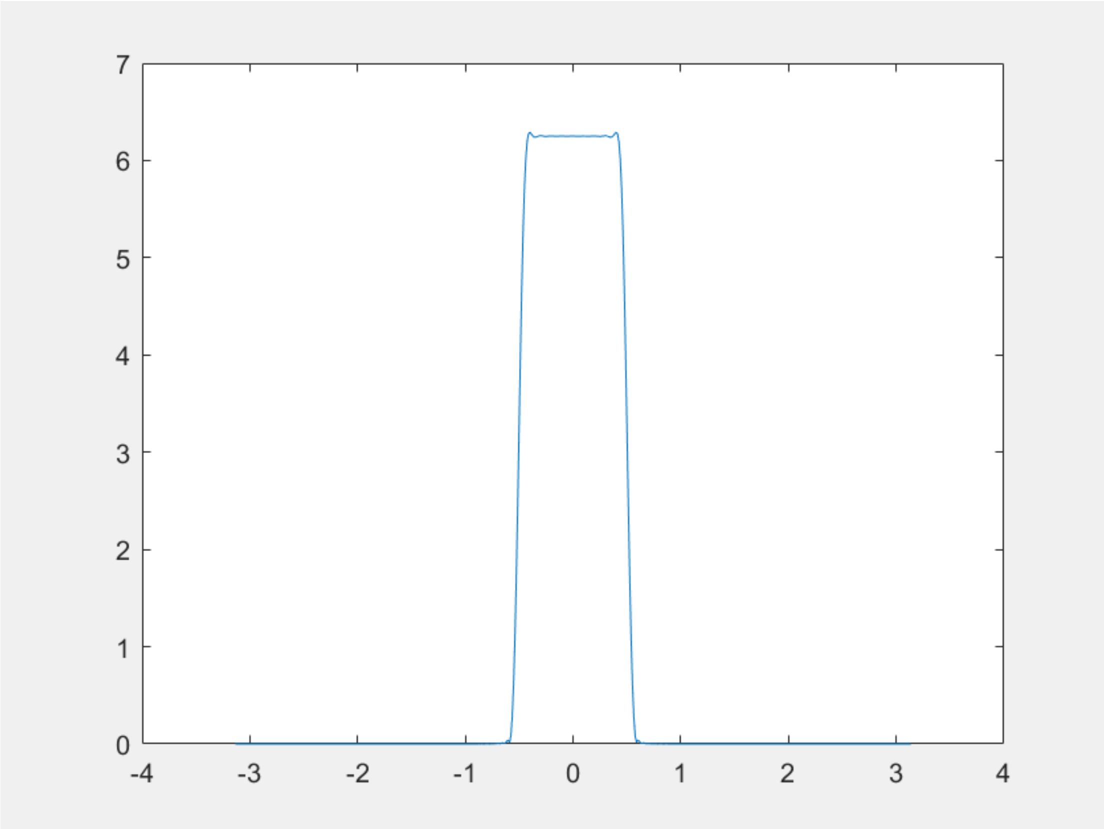
(d)(15%) Use the MATLAB function **plot** to plot $w[n]$ vs n.



(e) (15%) Use the MATLAB function **plot** to plot $y[n]$ vs n, where $y[n] = x[n]w[n]$, and $x[n]$ is the signal plotted in 1.(a).



(f) (20%) Use the MATLAB function **fft** directly to compute DFT of $y[n]$ in (e), and use the MATLAB function **plot** to plot the magnitude of the **fft** output vs frequency ω. The zero frequency should be also centered in your plot. Observe the *Gibbs phenomenon* here and give some explanation for comparison with 1.(b) in your report.



乘上 w[n] 之後，讓 x[n] 在遠離中央的信號表現被弱化，意味著讓原本因為取有限範圍而導致的 Gibbs phenomenon 變得不明顯。從結果來看也可以發現有這樣的情形，轉折點的失真情況較小。