Tutorial Questions:
LTIC Systems

1. **Impulse function and Digital Signals**

   (a) Draw three impulse function, $\delta[n-v]$ for values of $v=0$, $v=5$ and $v=-3$.

   (b) Given a function $g(n)=5$ draw $g(k)\delta[n-k]$ for values of $-5<k<5$:

   (c) If a continuous sine wave is defined as $x(t)=a\sin(t2\pi f)$ define the digital version using n for the samples and T_s seconds for the sample interval.

   (d) State the sample frequency of this digitized sine wave (remember to include the units):

   (e) If the frequency of the sine wave is 8000 Hertz what is the period (remember to include the units)?

2. **Linear Time Invariant Systems and Digital Convolution**

   (a) What is the *Principle of Superposition* and why is it useful?

   (b) Draw the system diagram using time delays, addition and multiplication for a moving average filter,

$$y[n]=\frac{x[n]+x[n-1]+x[n-2]+x[n-3]+x[n-4]}{5}$$

   (c) Calculate the impulse response of this moving average filter (5 stage) showing all steps:

   (d) Convolve, showing all calculation steps this moving average filter with a unit step function,

$$u[n]=\begin{cases}1 & \text{if} \quad n\geq 0\\ 0 & \text{if} \quad n<0\end{cases}.$$

   (e) $y[n]=\frac{1}{4}\left(x[n+1]+x[n]+x[n-1]+x[n-2]\right)$ and $y[n]=\frac{1}{4}\left(x[n]+x[n-1]+x[n-2]+x[n-3]\right)$ are 4 term non-causal and causal moving average filters respectively. What does *non-causal* mean? (Explain in 1 sentence.)

   (f) The equations for these 4 term moving average filters are known as a difference equations. Most difference equations for Linear Time Invariant (LTI) systems can be put into the form:

$$\sum_{m=0}^{N}a[m]y[n-m]=\sum_{m=0}^{M}b[m]x[n-m].$$

   Place the 4 term moving average filters into this more general form.

   (g) Convolve a 2 term causal moving average filter $y[n]$ with the following signal:

$$f[n]=\begin{cases}2 & \text{when} \quad n=3,\\ 0.5 & \text{when} \quad 0\leq n\leq 2,\\ 0.7 & \text{when} \quad 4\leq n\leq 7,\\ 0 & \text{everywhere else.}\end{cases}$$

   Show all essential working and steps.