Tutorial Questions:
Sampled Signals

1. Sketch 3 cycles of a cosine wave with frequency 125Hz and amplitude $A = 1.5$ with zero phase.
   Hint: A cosine wave has equation $x(t) = A\cos(2\pi ft + \phi)$.

2. Sketch the above waveform again but include discrete points at which sampling occurs for a sampling frequency of 150Hz, assuming the first sample occurs at $t = 0$.

3. Sketch the above waveform again but include the aliasing frequency.
   Hint: An aliasing frequency occurs at $f_{\text{alias}} = f - f_s$.

4. The above waveform is now sampled at twice the signal frequency, i.e. $f_s = 2 \times f = 2 \times 125 = 250$Hz. Resketch the waveform along with signal that could be assumed from the discrete samples upon conversion back to an analogue form.

5. Draw the signal that originates from a signal component of the sampled signal that was drawn above, sampled at the Nyquist rate. Explain what you have drawn.
   Hint: Signal components occur at $n \times f_s - f$ and $n \times f_s + f$ where n is an integer.

6. What is the purpose of antialiasing filtering?

7. Reconstruction Filtering:
   (a) What is the purpose of a reconstruction filter?
   (b) State the theoretical relationship between f_s and the bandwidth B of an ideal reconstruction filter.
   (c) Real world filters are not ideal. What does this mean when you want to use a real world filter for reconstruction of an analogue signal?

8. What are all the frequency components below $(3.5 \times f_s)$Hz that theory predicts will be present in sampled waveforms.

9. List the frequency components below 375kHz that theory predicts would be present in the sampled signal when $f_s = 150$kHz and $f_{\max} = 140$kHz.