# Homework 5 Representing sound

1. An airline company is making noise-cancelling headphones used to provide a quiet environment for travellers.

The headphones consist of:

* Two small speakers
* One microphone
* A programmable microprocessor with permanent memory
* One analog-to-digital convertor (ADC)
* One digital-to-analogue convertor (DAC)
  1. Firstly, external sound around the user is recorded by the microphone. What type of signal is output from the microphone? [1]
  2. This signal is passed into the analogue-to-digital convertor where it is sampled to produce a digital version of the sound recorded. Explain how this sampling process is achieved. [3]
  3. The choice of sampling frequency should be made based on the Nyquist theory. Explain, with a suitable formula, how this sampling rate can be determined in order to replicate the original signal. [2]
  4. The maximum frequency humans hear is 22,000 Hertz.  
       
     Components inside the headphone used to sample the ambient sound work at a sampling rate of 30,000 Hertz.  
       
     The signal received by the processor is inverted and transmitted to the speakers. The DAC changes the digital signal into an analogue voltage signal used to drive the speakers.  
       
     Evaluate how effective the speakers will be at cancelling the sound recorded by the microphone. [2]
  5. The processor requires a buffer to hold 2 seconds of stereo audio with left and right channels. The headphones sample sound at a resolution of 16 bits. Calculate how big the buffer will need to be in kB. [3]

1. A manager uses her mobile phone to record voice memos for later transcription when she returns to the office.

The diagram below shows a portion of the phone’s memory containing three samples of the original sound wave.

|  |
| --- |
| 1001 1011 1110 0101 |
| 1111 0001 1111 1111 |
| 0010 1101 1111 0010 |

1. What sampling resolution has been used? [1]
2. The phone recorded the audio at a sampling rate of 96,000 Hertz. Explain what this means. [2]
3. The manager is finding she is running out of storage space when making just a few recordings. She would like to be able to store more recordings and has the option to adjust the sampling rate.

Explain how lowering this value will create smaller files. [2]

1. There is 1 GB of storage left on the phone. Estimate how many complete 20 second recordings could be made if the sampling rate is 44 KHz with an 8 bit resolution. [2]

[Total 18 Marks]