Answers to Coursebook questions – Chapter F2

1 **a** $7 = 4 + 2 + 1 \to 111$

b $19 = 16 + 2 + 1 \to 10011$

c $67 = 64 + 2 + 1 \to 1000011$

2 **a** $01001 = 0\times 2^4 + 1\times 2^3 + 0\times 2^2 + 0\times 2^1 + 1\times 2^0 = 8 + 1 = 9$

b $11101 = 1\times 2^4 + 1\times 2^3 + 1\times 2^2 + 0\times 2^1 + 1\times 2^0 = 16 + 8 + 4 + 1 = 29$

c $10101 = 1\times 2^4 + 0\times 2^3 + 1\times 2^2 + 0\times 2^1 + 1\times 2^0 = 16 + 4 + 1 = 21$

3 We look for the **smallest** power of 2 that will exceed the given number.

a $2^4 = 16$, we do not exceed 16 with the 4th power so we need 5.

b $2^5 = 32$ so we need 6.

c $2^6 = 64$ so we need 7.

4 The **smallest** power of 2 that will exceed 1453 is (by trial and error) $2^9 = 512$, $2^{10} = 1024$, $2^{11} = 2048$, so 11 bits is what is required.

5 $2^5 = 32$, so 32 levels.

6 With 5 bits we have $2^5 = 32$ quantization levels.

The range of the data is 20 mV and so $\dfrac{20}{32} = 0.625\text{ mV}$.

7 With a high value of *n* we have very many quantization levels and so a small quantization error. The disadvantage is that very many bits need to be stored somewhere.

8 An analogue signal is a continuously varying signal, whereas a digital signal takes one of two possible values (0 and 1).

9 Analogue:

i the sound of your voice,

ii the output of a data logging sensor for temperature, voltage, pressure etc.,

iii the electrical signal carrying a telephone conversation along a copper wire.

Digital:

i the signal travelling in an optical fibre carrying a telephone conversation,

ii the image in a digital camera,

iii the signal sent by a computer to a laser printer.

10 Both are analogue signals. In the first case it is an electromagnetic wave, AM or FM modulated, that is sent from a radio station broadcasting antenna to your radio's antenna. The sound emitted from the loudspeaker is ordinary sound and so analogue.

11 A binary code is the equivalent value of a signal in binary. A digital signal is the representation of this value in terms of square waves.

12 **a** Sampling means measuring the value of a signal at a particular time.
Sampling frequency is the frequency at which the measurements are made.

b The higher the sampling frequency the easier it is to reconstruct the signal from its samples.

c **i** See graph in answers (see page 812 in *Physics for the IB Diploma*).

ii It is impossible to reconstruct the signal – the sampling frequency is too low.

13 The Shannon–Nyquist theorem refers to the conditions under which a signal may be accurately reconstructed from its samples. It states that for the reconstruction to be possible the sampling frequency must be at least twice the highest frequency in the signal.

14 See diagram on page 812 in *Physics for the IB Diploma*.

15 We assign 0 to the low flat line and 1 to the high line so as to get

001 100 001 111 100 101 100

16 The complete solution is on page 812 in *Physics for the IB Diploma*.

17 The complete solution is on page 813 in *Physics for the IB Diploma*.

18 The complete solution is on page 813 in *Physics for the IB Diploma*.

19 **a** The bit rate is equal to $f_{\text{sampling}} \times n$, where n is the number of bits and so equals $5.0\times10^{3}\times8=40\ \text{kbit s}^{-1}$.

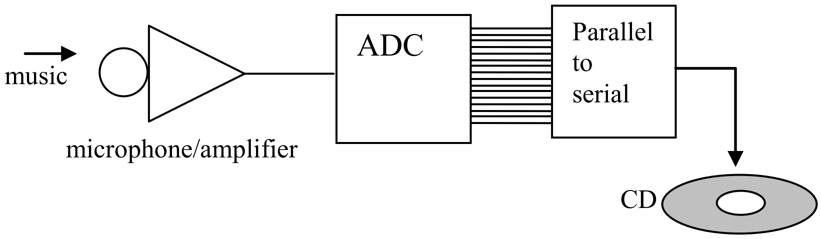
b The bit duration is the reciprocal of the bit rate, i.e. $\dfrac{1}{40\times10^{3}}=0.025\ \text{ms}=25\ \mu\text{s}$.

20 **a** The bit rate is $44.1\times10^{3}\times32=1411\ \text{kbit s}^{-1}\approx1.4\ \text{Mbit s}^{-1}$.

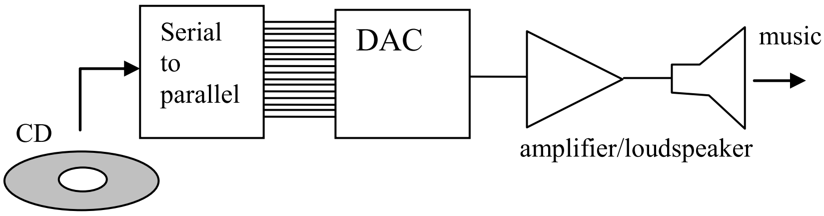
b $\dfrac{1}{1.411}=0.709\ \mu\text{s}$.

21 The time is $\dfrac{1}{4.0\times10^{3}}=2.5\times10^{-4}\ \text{s}=0.25\ \text{ms}$.

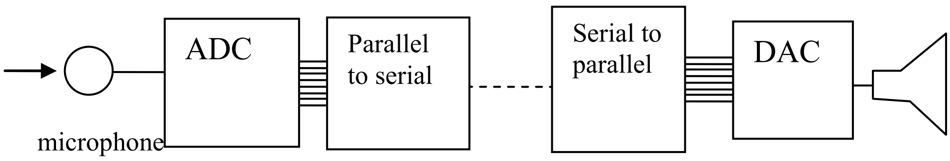
22 **a** Recording



b Playback



23

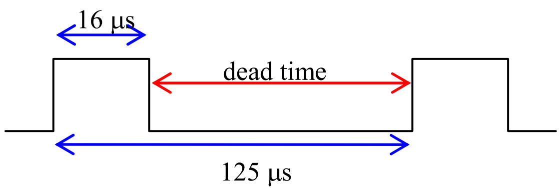


24 The parallel to serial converter transmits the bits in a sample one by one along one conduction line. It would be expensive and impractical to have 8 different wires running parallel to each other.

25 The transmission of many different signals on the same transmission line.

26 **a** The times at which samples are taken are separated by

$$\frac{1}{8.0\times10^{3}} = 1.25\times10^{-4}\ \text{s} = 125\ \mu\text{s}.$$



The dead time is therefore (see diagram) $125 - 8\times 2.0 = 109\ \mu\text{s}$ (since there are 8 bits in the sample.

b $\frac{109}{16} = 6.8 \rightarrow 6$ more.

c It would decrease because the time in between the samples would be reduced.

27 The Schmitt trigger uses the comparator property of an op-amp (i.e. the output depends on whether the input signal is smaller or greater than a reference voltage value) except that there are two reference voltage values that the input signal is compared to. There is one value when the input signal is increasing and another when it is decreasing.