Q1

Modem – Modem or modulator demodulator does exactly this it take the analog signals from the internet and converts them into digital and vice versa.

Router – router splits the access to the internet to multiple different devices be it through lan or wifi, allowing multiple users to access the internet through the modem. Also allows for secure networking be it adding in addition devices printers etc or accessing multiple devices.

(Majority of household connectors now are modem and router in 1 )

Wifi – The router is constantly sending out radio waves either at 2.4GHz high range slower speed or 5GHz shorter range higher speeds cannot penetrate walls or floors, on a specified channel. With 2.4GHz having 3 non overlapping channels whereas 5GHz has 25 non-overlapping allowing for a wider selection if the network would be otherwise crowded by other close networks(this may be common in unit complexes, and business districts holding many stores). When a signal is sent from a device a built in adapter translates data (digital) into radio signals and transmits into the air via an antenna, when the router waves receive this signal it decodes it and sends information along the chain.

Diagram

Q2

a) The neighbouring channels are such that the frequencies are quite obviously different. Each station is related in the fact they sit on what is known as a centre frequency and they are 0.8 MHz different as this would be the channels that do not overlap causing interference with each other.

b)i) Yes. Bandwidth maximum is 17.5kHz double of this would be 35khz the sampled rate is 38000 which is indeed higher than the 35000 required therefore the original signal would be reproduced without loss.

ii) Frequency \* bit depth \* channels  
=38,000 \* 64 \* 2  
=4,864,000bps

Q3) bit depth 5 bits = 25 = 32   
Highest available quantisation for precision factor is as follows  
range is -15 to 20 can see this as a ratio value 3 : 4 , 32 possible placements with 1 of these being zero allowing an equation of 31/7\*ratio to give each side with this working out to be 13.2 and 17.7 can safely have 13 allocated minus and 18 allocated positive thus giving 31   
The next will be to work out widths of the range in need   
range/allocated bits  
15/13 for minus = 1.154 rounded to 2 decimal 1.16  
20/18 for positive = 1.1111recurring to 2 decimal 1.12  
Greater of the numbers to give full range required = 1.16  
the following table depicts the precise values alongside the easier set allocation of assumption for calculations of the width of = 1.25 (given tutorial learnings)  
I felt this explanation was needed as the rest of the calculations made will be done with the precise method I have depicted.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Bit | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| level | -15  -15.08 | -13.75  -13.92 | -12.5  -12.76 | -11.25  -11.6 | -10  -10.44 | -8.75  -9.28 | -7.5  -8.12 | -6.25  -6.96 | -5  -5.8 | -3.75  -4.64 | -2.5  -3.48 | -1.25  -2.32 | 0  -1.16 | 1.25 0 | 2.5 1.16 |
| Bit | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 |
|  | 3.75  2.32 | 5  3.48 | 6.25  4.64 | 7.5  5.8 | 8.75  6.96 | 10  8.12 | 11.25  9.28 | 12.5  10.44 | 13.75  11.6 | 15  12.76 | 16.25  13.92 | 17.5  15.08 | 18.75  16.24 | 20  17.4 | 21.25  18.56 |
| Bit | 30 | 31 |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 22.5  19.72 | 23.75  20.88 |  |  |  |  |  |  |  |  |  |  |  |  |  |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original Sample value | -6.1 | 7.5 | 16.2 | 19.7 | 11.0 | -5.5 | -11.3 | -9.4 | -6 |  |
| Using round-up (scale-up rule) – 1.25 | -6.25  bit7 | 7.5 bit18 | 16.25 bit10 | 20 bit28 | 11.25  bit21 | -5 bit8 | -11.25 bit3 | -10 bit4 | -6.25 bit7 |  |
| Using round-up (scale-up rule) – 1.16 | -5.8  bit8 | 6.96 bit19 | 16.24 bit12 | 19.72  bit30 | 11.6  bit23 | -5.8 bit8 | -11.6 bit3 | -9.28 bit5 | -5.8 bit8 | Average error |
| Quantisation error (%) 1.25 | 2.5% | 0% | 0.3% | 1.5% | 2.3% | 9.1% | 0.4% | 6.4% | 4.2% | 2.97% |
| Quantisation error (%)  1.16 | 4.9% | 7.2% | 0.2% | 0.1% | 5.5% | 5.5% | 2.6% | 1.3% | 3.3% | 3.4%  (remove the 7.2 and is 2.93%) |
| Binary – 1.25 | 00111 | 10010 | 01010 | 11100 | 10101 | 01000 | 00011 | 00100 | 00111 |  |
| Binary – 1.16 | 01000 | 10011 | 01100 | 11110 | 10111 | 01000 | 00011 | 00101 | 01000 |  |

3b) from the table above can see the error percentile rates with the given values of the question the bit rate number scale worked out better with the less precise method however since the data entry is limited in size can assume this is not the case as per removing the odd value that is high within the precise value can see the average error % is lower for the value. By increasing the precision of each point the error factor can be reduced, this can be achieved by having a smaller value range or increasing the bit scale.

3c) range is once again 3 : 4 ratio  
7 bit is 128 placement values with 1 being a zero value giving us 127/7 \* ratio  
negative placement 54.4 positive placement 72.5 therefor 54 for negative 73 for positive 1 for zero value which will be bit 54  
The next will be to work out widths of the range in need   
range/allocated bits  
15/54 for minus = 0.2777recurring rounded to 2 decimal 0.28  
20/73 for positive = 0.27397 to 2 decimal 0.27  
Greater of the numbers to give full range required = 0.28  
Double check working  
0.28 \* -54 = -15.12 (enough for the range)  
0.28 \* 73 = 20.44(enough for scale range)

Worked examples   
to find the value of the bit it will be the following formula will be used   
(Sample value/range (rounded to bit)) \* range  
eg.   
first value -6.1  
(-6.1/0.28) = -21.78 = rounded to whole -22  
-22 \* 0.28 = -6.16  
bit value = rounded range + 0 bit marker  
-22 + 54  
bit value = 32

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Original Sample value | -6.1 | 7.5 | 16.2 | 19.7 | 11.0 | -5.5 | -11.3 | -9.4 | -6 |  |
| Using round-up | -6.16 bit32 | 7.56  Bit81 | 16.24 bit112 | 19.6  bit124 | 10.92  Bit93 | -5.6 bit34 | -11.2 bit14 | -9.52 bit20 | -5.88 bit33 | Average  error |
| Quantisation error (%) | 1% (0.98) | 1% | 0.2% | 0.5% | 0.7% | 0.9% | 0.9% | 1.3% | 0.3% | 0.76% |
| Binary | 0100000 | 1010001 | 1110000 | 1111100 | 1011101 | 0100010 | 0001110 | 0010100 | 0100001 |  |

As the table above depicts from the original errors from 5 bit to 7 bit, the 7 bit reduces errors by a significant margin. With only 1 of the values being above 1% due to the fact it is a mid-value difference of the equation separator.