Question 1: (5 points)  
The following sequence of real numbers has been obtained sampling an audio signal: 1.8, 2.2, 2.2, 3.2, 3.3, 3.3, 2.5, 2.8, 2.8, 2.8, 1.5, 1.0, 1.2, 1.2, 1.8, 2.2, 2.2, 2.2, 1.9, 2.3, 1.2, 0.2, -1.2, -1.2, -1.7, -1.1, -2.2, -1.5, -1.5, -0.7, 0.1, 0.9 Quantize this sequence by dividing the interval [-4, 4] into 32 uniformly distributed levels by placing the level 0 at -3.75, the level 1 at -3.5, and so on and level 31 at 4.00. Also, remember that quantization should result in least error

* Write down the quantized sequence. (4 points)

Given following equation such that:

We can quantize the sequence to following, we will round to the nearest integer to result in least error:

1.75, 2.25, 2.25, 3.25, 3.25, 3.25, 2.5, 2.75, 2.75, 2.75, 1.5, 1.0, 1.25, 1.25, 1.75, 2.25, 2.25, 2.25, 2.0, 2.25, 1.25, 0.25, -1.25, -1.25, -1.75, -1.0, -2.25, -1.5, -1.5, -0.75, 0.0, 1.0

* How many bits do you need to transmit it? (1 points)

Given following equation to calculate the bits:

Therefore, total bits would be:

Question 2: (10 points)  
A high-definition film color camera has 1080 lines per frame, 1920 pixels per line, with a 24 Hz capture frame rate. Each pixel is quantized with 12 bits per channel during the quantization process. The capture pipeline employs the follow sequence

1. YUV 4:2:0 color subsampling scheme
2. An optional feature, to the signal to standard definition CIF (352x288)
3. An obligatory MPEG2 compression phase
4. Disk write with a varying disk write speed (12 to 36 Mbytes per second)

Answer the following questions

* If the second optional feature is off, what minimal compression ratio needs be achieved by the third compression step process? (4 points)

YUV equivalent bits:

Bit rate for high-definition film color camera can be calculated as:

Compression ratio:

* If the second optional feature is turned on to produce CIF format, how does your previous answer change? (3 points)

YUV equivalent bits:

Bit rate for CIF can be calculated as:

Our disk writing speed is at least 12 Mbytes, which is way higher than the bit rate CIF produced. Therefore, we don’t need to compress the signal. Hence, the ratio is changed to 1:1

* If original pixels were square, how do the pixel stretch with the second optional feature turned on.? (3 points)

According to the pixel aspect ratio equation:

Question 3: (15 points)

Temporal aliasing can be observed when you attempt to record a rotating wheel with a video camera. In this problem, you will analyze such effects. Assume there is a car moving at 36 km/hr and you record the car using a film, which traditionally records at 24 frames per second. The tires have a diameter of 0.4244 meters. Each tire has a white mark to gauge the speed of rotation. (15 points)

* If you are watching this projected movie in a theater, what do you perceive the rate of tire rotation to be in rotations/sec? (3 points)

Rotation can be calculated as:

* If you use your camcorder to record the movie in the theater and your camcorder is recording at one third film rate (ie 8 fps), at what rate (rotations/sec) does the tire rotate in your video recording (6 points)

Nyquist’s sampling frequency can be calculated as:

Therefore, we will witness aliasing at 8 fps

We will see the wheel rotating backwards at 0.5 round per second

* The driver decides to participate in race, and buys tires that safely allow a max speed of 180 km/hr. What must be the diameter of the tire if no temporal aliasing needs to be witnessed in the recording? (6 points)