Q1

[1]

(a) Since the maximum frequency that needs to be represented is the limit of human hearing (20 KHz), then by Nyquist theorem we should sample at a rate greater than twice the maximum frequency which is 40KHz.

The additional 4.1 KHz is used as a room for higher ranges resulting from reconstructing of the continuous signal from the discrete samples, so that interpolation is not difficult or costly.

(b) Since intelligible speech requires frequencies only up to 4 KHz, then the Nyquist rate is twice that = 8 KHz

[2]

It is true the human voice contains as high as 4 KHz frequencies, however they are not necessary to discern the words spoken and understand the speech reliably, they might be important for the pitch and fine details, hence a lot of these high frequencies are not transmitted over the phone, consequently people may sound different on the phone from than in person.

[3]

The maximum bit rate allowable over telephone lines = $7\ bits/sample\ \times 8\ KHz = 56\ kbs$

The bit rate of music coming off a CD = $16\ bits/sample\ \times 8\ KHz = 705.6\ kbs$

which too much high for a bit rate of a modem, so it is not enough to support CD quality audio transmission

Q2

[1] The color gamut of a CRT screen is the color triangle of the RGB color space it does not cover the entire range of possible chromaticity. The corners of the triangle are the primary colors for this gamut, which covers a significant portion of the visible color space. The limitations in CRT are due to the phosphors in the screen which produce red, green, and blue light.

[2] Because YCrCb separates the luma from the chrominance, which makes it easier to compress, to store and transmit in high resolution, and to modify the intensity or color without having to access all channels like the case in RGB.

Moreover, It is human perceptible and more suitable to deal with real world images.

In addition, It allows flexibility in sub sampling intensity and colors in different portions as required.

[3]

(a) RGB: Web design uses color as RGB and I would like my art work to be in the highest quality possible, showing all fine details and colors.

(b) 1-bit grayscale, only black and white is required

(c) CMYK as printers use cyan, magenta, yellow, black

Q3

[1]

with color sub-sampling scheme 4:2:0

for every 4 pixels: $\frac{4\times8+2\times8+0\times8}{4} = 12\ bits/pixel$

bit rate = $450\frac{line}{frame} \times 520\frac{pixel}{line} \times 25\ Hz\ \times 12\ \frac{bits}{pixel} = 70.2\ Mbps$

[2]

with color sub-sampling scheme 4:2:0

for every 4 pixels: $\frac{4\times8+2\times6+0\times6}{4} = 11\ bits/pixel$

bit rate = $70.2\ \times\frac{11}{12} = 64.35\ Mbps$

the minimum size of the hard disk required to store 10 minutes of video = $10\ \times 60\ \times 64.35 = 38610$ Mbits

[1]

with color sub-sampling scheme 4:2:2

for every 4 pixels: $\frac{4\times8+2\times8+2\times8}{4} = 16\ bits/pixel$

bit rate = $450\frac{line}{frame} \times 520\frac{pixel}{line} \times 25\ Hz\ \times 16\ \frac{bits}{pixel} = 93.6\ Mbps$

[2]

with color sub-sampling scheme 4:2:2

for every 4 pixels: $\frac{4\times8+2\times6+2\times6}{4} = 14\ bits/pixel$

bit rate = $93.6\ \times\frac{14}{16} = 81.9\ Mbps$

the minimum size of the hard disk required to store 10 minutes of video = $10\ \times 60\ \times 81.9 = 49140$ Mbits