1) 32-QAM is 5 bit per symbol, at 25Mbaud rate capacity is 125 Mbps

2) 16-QAM is 4 bit per symbol

32-QAM is 5 bit per symbol

64-QAM is 6 bit per symbol

128-QAM is 7 bit per symbol

16 to 32 QAM yields 80 % increase in capacity.

64 to 128 QAM yields 86 % increase in capacity.

3) The bandwidth of the signal is 25 MHz. The level of the signal at the receiver is 50mW. The average power of the noise 5mW. Calculate the capacity using the Shannon-Hartley theorem:

$$C = B \cdot \log_2(1+\frac{S}{N}) = 25 \cdot 10^6 \cdot \log_2(1+\frac{50 \cdot 10^{-3}}{5 \cdot 10^{-3}}) = 86.5 \cdot 10^6 \text{ bps}$$

4) The bandwidth of the signal is 25 MHz. The level of the signal at the receiver is -50dBm. The average power of the noise -70dBm. Calculate the capacity using the Shannon-Hartley theorem!

dBm is power logarithmic ratio to 1 mW by formula $P(\text{dBm}) = 10 \cdot \log 10\left(\frac{P(\text{W})}{1\text{mW}}\right)$

The S and N are expressed in W the following way

$$S(\text{W}) = 1\text{mW} \bullet 10^{\frac{S(\text{dBm})}{10}} = 10^{-8}$$

$$N(\text{W}) = 1\text{mW} \bullet 10^{\frac{N(\text{dBm})}{10}} = 10^{-10}$$

$$C = B \cdot \log_2(1+\frac{S}{N}) = 25 \cdot 10^6 \cdot \log_2(1+\frac{10^{-8}}{10^{-10}}) = 1.7 \cdot 10^8 \text{ bps}$$

5)--------

6) A square pulse with amplitude Sm and duration Δt is applied to the integrating resistor R and capacitor C circuit.

The frequency transfer function is: $\underline{K}(f) = \frac{1}{1+\mathrm{j}2\pi fRC}$

Spectral density of the output signal of the circuit is:

$$S_{OUT}(f) = S_{IN}(f) \cdot \underline{K}(f) = S_m \cdot \Delta t \cdot \operatorname{sinc}(2\pi f \cdot \frac{\Delta t}{2}) \cdot \frac{1}{1+\mathrm{j}2\pi fRC} =$$

$$= \frac{S_m \cdot \Delta t}{\sqrt{1+(2\pi fRC)^2}} \cdot \operatorname{sinc}(2\pi f \cdot \frac{\Delta t}{2}) \cdot \mathrm{e}^{-\mathrm{j}2\pi fRC}$$

7) We are intending to save the human voice to the file. Prior to this, it should be discretized and quantized. Assume that the highest spectrum component that we need has a frequency of 2 kHz.

Each sample has 256 quantization levels. The length of the record is 10 seconds. Calculate the size of the file!

The sampling frequency will be $F_S = 2\cdot\ 2\text{kHz}=4\text{kHz}$ by Nyquist criteria

256 quantization levels are 8 bits

Sampling period is $\Delta t = \frac{1}{F_S} = 0.25\cdot\ 10^{-3} = 250\cdot\ 10^{-6}\text{s}$

The amount of samples taken in 10 seconds is $N = \frac{10}{250\cdot\ 10^{-6}} = \frac{1}{25}\cdot\ 10^{6} = 4\cdot\ 10^{4}$

And the length of the file is $L = N\cdot\ 8\text{ bits} = 32\cdot\ 10^{4}\text{bits}$ or 40 kB.