

KFUPM - COMPUTER ENGINEERING DEPARTMENT**COE-540 – Computer Networks****Quiz 02 – Due Feb 18th, 2015 – Take home quiz****Student Name:****Student Number:**

Solution:

a) Sending at the rate of b bits per second \rightarrow we are sending one byte (8 bits) every $T = 8 / b$ seconds.

\rightarrow fundamental frequency $f_0 = 1/T = b/8$ Hz.

Telephone channel bandwidth, $BW = 3$ kHz = 3000 Hz.

The question is how many multiples of f_0 we can fit in the telephone channel $BW \rightarrow$ number of harmonics = $\left\lfloor \frac{3000}{b/8} \right\rfloor = \left\lfloor \frac{24000}{b} \right\rfloor$, where $\lfloor x \rfloor$ is the largest integer smaller or equal to x . Substitute for b the values given in first column of table in Figure 2-2 and you get the rest of the values.

b) Using Shannon capacity $C = B \log_2(1 + SNR) = 3000 \log_2(1 + 10^{(30/10)}) = 29.9$ kb/s

c) When noise is ignored \rightarrow We can use Nyquist criterion \rightarrow Every 1 Hz can do 2 symbols per second, or $C = 2B \log_2(M)$ - where M is the alphabet size.

We can choose M arbitrarily large $\rightarrow C =$ infinity.

d) To achieve $C = 29.9$ kb/s using a bandwidth of 3000 Hz

$$C = 2B \log_2(M) \rightarrow M = \text{roundup}(2^{(C/2B)}) = 32 \text{ symbols or signaling elements.}$$