**HW2 – Sample Answers**

**Problem 1**

* Given that the retransmission of failed packets succeed, for every p packets that fail, there is a total of (1+ p) \* RTT time that the sender would have spent - where p \* RTT accounts for the retransmission of failed packets. Hence the formula for the throughput would be = frame size / [(1+ p) \*RTT]
* The expected time to deliver a packet can be calculated as

E = (1- p) \* RTT + p \* (RTT+E).  
E = RTT/(1-p)  
Expected Throughput = [(1-p) \*framesize]/RTT

**Problem 2**

* Set of 4D vectors- (1, 2, 3, -4) (1, 0, 1, 1) (-6, 1, 4, 2) (-1, -22, 7, -6)
* Assuming sender wants to send 1 bit per receiver, i.e. either a 0 or a 1 per each vector – say bi indicating bit to be sent to the ith receiver then the sender needs to just do an element by element multiplication, add and send it.
* Each receiver just does a dot product of the received vector with vi to obtain bi. ri = s.bi The orthogonality helps over here because it ensures that when the receiver decodes the message, there is no interference from bits meant for other users.
* Dot product of two different code vectors won’t be zero, if the vectors are not orthogonal
* If two carrier frequencies are too close, they might interfere with each other’s signals (called inter-channel interference).
* Two approaches used to prevent the problem

(1) Set up guard bands between each carrier frequency.

(2) Use orthogonal FDM which allows overlapping between nearby carrier frequencies.

**Problem 3**

* The AM band is between 535 kHz and 1605 kHz. Each band is restricted to 10 kHz, hence only samples restricted to 5 kHz can be sent on top of these radios. This supports the perception that AM is for talk shows and not music.
* Differences between AM radio and FDMA multi user communication –

1. In AM, there is a single carrier frequency with the amplitude of the carrier wave being varied in proportion to the waveform. In FDMA, a given band is split into multiple smaller frequency sub bands which is then used to serve different users.

* If a law mandates that all AM radio becomes digital, then receivers need to be replaced because AM receivers just reconstruct the signal by just tracing the envelope of the received signal. Instead if the messages are transmitted digitally, then the first the digital message must be received followed by processing to reconstruct the audio signal from the compressed mp3 information.
* The audio quality might not get increased. This is because, to digitize the data, the receiver

need to do sampling and the sampling rate might need to be low to accommodate the

limited bandwidth of AM, which will result in poor fidelity. Furthermore, many audio

compressing algorithms are not lossless, which worsens the audio quality.