

QR48/CSCI E-2 Problem Set 4

(due Wednesday April 22 at noon; as always you must work in pairs)

1. (9 points total) The world record jump rope speed is 190 jumps in 30 seconds. For the purposes of this problem assume that the speed of the jump rope was constant throughout the 30 seconds and that the motion of the jump rope does not vary on individual jumps.
 - A) (2 points) What was the period of the jump rope in during the record-setting 30 seconds?
 - b) (1 point) What was its frequency?
 - c) (2 points) Suppose that a video camera positioned to view the jump roper in profile recorded the record-setting event at a rate of 24 frames per second. Will the jump roping appear accurately on the video recording? Explain why or why not.
 - d) (4 points) At what frame rate would the video recording appear to show that the jump rope moved only half as fast? At what frame rate would the recording appear to show that the jump rope wasn't moving at all?

2. (11 points total) 15 year old Alice is sitting in her bedroom talking on her cell phone to her friend Bob and listening to music. She hears Bob at 42dB and the music at 36dB. Her mom calls her from downstairs to tell her to walk the dog. She hears her mom at 40dB. For the purposes of this problem assume all sounds are in the same range of frequencies, are received in phase with each other and are in the band defined as 300Hz to 3000Hz.
 - A. (3 points) How loud is the music? How loud is Alice's mom? How loud is Bob? (Convert the sound sources to their absolute ratio to the power of the softest sound a human can hear (S)).
 - B. (2 points) Alice's mom may need to yell louder to get Alice's attention. Calculate the signal to noise ratio as a unit-less number (where the "signal" is Alice's mom).
 - C. (2 points) What is the bandwidth of the communication channel?
 - D. (2 points) What is the channel capacity of the communication channel with Alice's mom?
 - E. (2 points) How much more power does Alice's mom need to use to increase her decibel level to 46dB?

3. (15 points total) The WHRB radio station transmits at 95.3FM, which means that it transmits in the range between 95.2 and 95.4 MHz. Suppose that the power of radio noise is 750W.
 - A. (1 point) What is the bandwidth of FM radio transmission?
 - B. (3 points) Suppose WHRB decides to upgrade their transmitter to be rated at 50,000 W. What is the new channel capacity of the FM broadcast?
 - C. (3 points) While FM radio sounds pretty good, it sounds noticeably worse when compared to listening to a CD. Stereo CDs transmit on two channels using a sampling rate of 44.1KHz, encoded using 16 bits per sample. Assuming that no compression is used, what would be the minimum capacity needed for a channel to transmit CD-quality sound?
 - D. (3 points) How much power would WHRB need in order to transmit CD-quality sound? Is the 50,000 W transmitter up to the task?
 - E. (2 points) XM radio dedicates 4 MHz of bandwidth for transmitting content. How much power would be required for CD-like, stereo transmission on XM?
 - F. (2 points) Suppose instead that XM transmits 5:1 surround sound? (5:1 surround sound transmits audio on 5 separate channels.) How much power is needed now?
 - G. (1 point) Based on your answers above, which radio transmission technology is 'greenest'?

4. (5 points total) The musical pitch middle C has frequency 261.63 Hz. Moving up one octave doubles the frequency of the pitch.
- A. (2 points) The human ear can hear frequencies as high as 20kHz. What is the frequency of the highest C note that the human ear can hear?
 - B. (1 point) The G note above middle C has frequency 392 Hz. An analog telephone carries the frequencies 300-3400 Hz. How many octaves above this G note is the highest G that can be heard over an analog telephone?
 - C. (1 point) A digital telephone transmission samples at a rate of 8kHz. How many octaves above the 392 Hz G note is the highest G that can be captured accurately over a digital telephone transmission?
 - D. (1 point) A CD samples at 44.1 kHz. What is the highest frequency G that can be recorded on a CD?