**MATH233 Unit 4 Individual Project**

**NAME (Required): \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

Dr. Claude Shannon (1916 – 2001), “the father of information theory,” observed that the maximum error-free capacity in bits per second (bps) obtainable in a communication channel can be found by the Shannon-Hartley equation:

 bits per second

Above, , is the bandwidth of the channel in Hertz and is the signal-to-noise ratio of the channel. Since 0 does not make sense in this situation, assume that the formula below is correct:

This is a “pure” number with no unit labels on it. The value of is called *Shannon’s Capacity Limit* or *channel capacity*. This is the theoretical upper limit for the bits per second through the channel with a specific value and a specific given channel frequency bandwidth, , in Hz.

**Be sure to show your work details for all calculations and explain in detail how the answers were determined for critical thinking questions**. **Round all value answers to three decimals.**

1. In this assignment you will use the following version of the Shannon-Hartley equation.

 **bits per second**

In the table below, based on the first letter of your last name, choose a value from the stated range for the bandwidth, , for your communication channel’s bandwidth.For example, if your last name begins with A-F, and you choose 100,000,000 for your value of B, then your channel capacity function for this assignment would be:

 **bits per second**

Write your maximum error-free channel capacity function below the table.

|  |  |
| --- | --- |
| **First letter of your last name** | **Possible values for in Hz** |
| A–F | 100,000,000 – 125,000,000 |
| G–L | 150,000,000 – 175,000,000 |
| M–R | 200,000,000 – 225,000,000  |
| S–Z | 250,000,000 – 275,000,000 |

**State your channel capacity function here:**

1. Calculate the derivative of your channel capacity function with respect to What is the meaning of in the context of this channel capacity scenario? Show your work details.
2. Generate a graph of this function using Excel or another graphing utility. (There are free downloadable programs like [Graph 4.4.2](http://www.padowan.dk/) or [Mathematics 4.0](http://microsoft-mathematics.en.uptodown.com/); or, there are also online utilities such as [this site](https://www.desmos.com/) and many others.) Insert both the function and the graph into the Word document containing your answers and work details. Be sure to label and number the axes appropriately.
3. For your function from question #1 what is the instantaneous rate of change in maximum error-free channel capacity with respect to SNR, for ? Show your work details.
4. What is the equation of the tangent line to the graph of , when ? Show your work details.
5. In general, the Shannon-Hartley equation applies to any communication channel with a known bandwidth. For example, a device like a cable modem may have a very high SNR ( > 1000) but a fairly narrow bandwidth. The Data Over Cable Service Interface Specification (DOCSIS 3.0) requires that the downstream per channel bandwidth of a compliant cable modem must be either 6 MHz or 8 MHz wide. Research the Library or the Internet to find a reasonable downstream bandwidth in MHz of a commercially available brand of cable modem. State the name of the commercially available cable modem you found and give the reference for this information. Use that bandwidth together with a SNR = 1023 to find the channel capacity of the cable modem. Whether you have cable Internet service or not, are you getting this type of downstream service from your Internet Service Provider? What justification do you give for this answer? Show your work details on all calculations.

**References**

*Desmos*. (n.d.). Retrieved from https://www.desmos.com/

*Graph 4.4.2*. (n.d.). Retrieved from the Graph Web site: http://www.padowan.dk/

*Mathematics 4.0*. (n.d.). Retrieved from the Microsoft Web site: http://microsoft-mathematics.en.uptodown.com/