Programming Assignment

You can use any programming language you prefer (MATLAB, Python, C/C++, or Julia, for example). Write down your code as clearly as possible and add suitable comments. Turn in the hard copy of answers to each problem and submit your code to `ece154ucsd@gmail.com` with the exact subject `ECE 154C (HW1)`.

1. Write a program for a function `binaryHuffman(pmf)` that takes a probability vector `pmf` and outputs a binary Huffman code. For example,

```
["0", "10", "11"] = binaryHuffman([0.8, 0.1, 0.1])
```

   (a) Run the program for `pmf` $= \{0.9, 0.1\}$ and compute the average length of the resulting Huffman code.

   (b) Consider block lengths $n = 2, 5, 10$. For each block length, find the Huffman code and the average length per symbol.

   (c) Repeat (a) and (b) with $n = 1, 3, 5$ for probabilities `pmf` $= \{0.5, 0.25, 0.25\}$.

   (d) Repeat (a) and (b) with $n = 1, 2, 3$ for probabilities `pmf` $= \{0.53, 0.28, 0.1, 0.05, 0.04\}$.

2. Write a program for a function `ShannonFano(pmf)` that takes a probability vector `pmf` and outputs a Shannon–Fano code. Repeat the same experiments as in the previous problem.

3. Using the programs in the previous two problems, find a probability $p \in [0, 1]$ and a block length n such that the average length for the Shannon–Fano code for `pmf` $= \{p, 1-p\}$ is different from that of the Huffman code.

4. Consider a source with probability vectors $\{p, 1-p\}$. We find the average length per symbol when $n = 10$ symbols of this source is encoded using Huffman coding.

   (a) Using `binaryHuffman`, plot the average length per symbol. The plot should be evaluated at 100 values of p.

   (b) Find the average (over p) of the average length per symbol. Comment on how much a Bernoulli source with random bias $\mathsf{P} \sim \text{Unif}[0, 1]$ can be compressed on average.