1. Using the following HMM,

$$
tr = \begin{bmatrix}
.4 & .5 & .1 \\
.2 & .2 & .6 \\
.1 & .1 & .8 \\
\end{bmatrix};
$$

$$
e = \begin{bmatrix}
.3 & .7 \\
.4 & .6 \\
.9 & .1 \\
\end{bmatrix};
$$

$$
s = \{\text{'a', 'b'}\};
$$

and these training items $ab, aa, baa$, calculate $\bar{b}$ and $\bar{a}$ (for only one cycle). Show your work (which means showing how you also calculate $\alpha$, $\beta$, $\gamma$, $\xi$).

2. There is a file on the website `phonenumbers.txt` which contains a list of hypothetical phone numbers. Build a bigram model of those numbers. You result should be a grid of conditional probabilities for each combination of numbers possible along with word edge markers.

3. **non-programming option** Explain what the following terms mean using examples: LPC, spectrum, and cepstrum. (2pp. max)

**programming option** Create a function that can calculate $\alpha$ values. The function should take four arguments: i) HMM transitions; ii) HMM emissions; iii) a set of symbols; and iv) an input string.

4. **578 only**: Do the first question again starting with the following initial values.

$$
tr = \begin{bmatrix}
.3 & .3 & .4 \\
.2 & .2 & .6 \\
.1 & .1 & .8 \\
\end{bmatrix};
$$

$$
e = \begin{bmatrix}
.6 & .4 \\
.4 & .6 \\
.9 & .1 \\
\end{bmatrix};
$$

$$
s = \{\text{'a', 'b'}\};
$$

Are the values for $\bar{b}$ and $\bar{a}$ different from the first question?

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**Things to remember:**

1. This is due by **noon on May 7**.

2. Remember: nothing late. Don’t wait until the last minute to do this or print things or email things.

3. You may certainly talk to each other about this and other assignments, but everyone must turn in their own work. (If you do talk to others, I need to see evidence that you are doing more than listening and writing down what others say.)