

HW 3: Nod what ice Ed

[Re-submit Assignment](#)

Due May 2 by 11:59pm **Points** 100 **Submitting** a file upload

General Instructions:

As always, please read the assignment carefully, as failure to understand the details of the questions can result in errors. The final submission should have 4 files: a pdf with the written answer to question 1 and the drawings for the FSTs described in questions 2-4 in addition to separate .pl files for each of the three FSTs. Within each question, what you need to turn in is bolded, and there is a summary at the end of the document.

NOTE: Submitting prolog files that do not run will result in large deductions. If you are having trouble, you need to contact me early, as I will not be able to help you at the last minute via email.

Part 1: Buy Pie

As we saw in HW 1, sequences of phonemes can correspond to many different sequences of words. Although this does not bother us at all when we listen to speech, machines have an ever harder time that it may seem since many phonemes are very similar to one another. Consider the following pairs:

- [p] and [b]
- [t] and [d]
- [k] and [g]

QUESTION 1: How does the first item in each pair above differ from the second?

(Hint: if you are unsure, read about *phone properties* in the Ojeda textbook on page 57, and consult pages 335-337. Or you can look closely at the IPA chart.)

Question 2:

Draw an FST that can swap the following pairs of sounds: [p] and [b], [t] and [d], and [k] and [g]. The input alphabet is the set of phonemes listed under the phoneme set in the [CMU pronunciation dictionary page](http://www.speech.cs.cmu.edu/cgi-bin/cmudict) (e.g. AA, AE, AH, ...). *The output alphabet is exactly the same as the input alphabet.* Each string in the input language should be mapped to one or more similar string(s) in the output language, except that each B can remain a B or become a P, each P can remain a P or become a B, and so on with T/D and K/G.

(Hint 1: this type of FST is sometimes referred to as a *flower* FST!)

For example, here is the entry for the word *buy*:

BUY B AY

The input string

```
B AY
```

corresponds to the output strings

```
B AY
```

and

```
P AY
```

where each results from a different path in the FST.

What to turn in:

- a. Add a picture of your FST diagram (specified above) to your PDF submission.**
- b. Submit your FST (specified above) in a prolog file (.pl) using the prolog format used in HW 1. Name the file hw2q2.pl.**

As seen in class, transitions in prolog have the following form:

```
transition(State1, InputSymbol, State2, OutputSymbol).
```

For example, to go from state 15 to state 20, with input symbol a and output symbol x, we write:

```
transition(15, a, 20, x).
```

(Hint 2: What does the following transition do?

```
transition(20, Sym, 26, Sym).
```

What about:

```
transition(20, Sym, 26, Sym) :- Sym \= eps.
```

You don't need to comment on this in your submission, but *think about what each transition does and why*. You can even try it out by writing a transition table and running it with fst.pl!)

Question 3:

Now create a similar FST, but one that allows only one substitution or zero substitutions. For example, with the input:

```
B AE T
```

But your new FST should only produce

B AE D

P AE T

B AE T

but

P AE D

is no longer allowed since it requires two substitutions.

What to turn in:

- Add a picture of your FST diagram to your PDF submission.**
- Submit your FST in a prolog file (.pl) using the prolog format used in HW 1. Name the file hw2q3.pl.**

Part 2: Aspire

You may have noticed that the /t/ sound is a little different in the words *top* and *stop*, and the /p/ sound is also a little different in *pat* and *spat*. This is because of aspiration. As we saw in class, in *top* and *pat*, there is a stronger burst of breath that comes out with the first consonant sound.

A (simplistic) phonological rule for aspiration in English goes as follows:

Voiceless stops are aspirated when they occur immediately before a stressed vowel, and there is no /s/ immediately preceding the voiceless stop.

For example, in *pat* [p^hæt] we get aspiration (indicated in IPA with a superscript "h"), but not in *spot* [spæt].

Let's now consider a version of the CMU pronunciation dictionary that has stress marked in the transcriptions. For example, the word *potato* looks like

P AH T EY1 T OW

where the 1 appended to EY means that the vowel is stressed. Every vowel can be unstressed, e.g. AA, EY, OW, or stressed, e.g. AA1, EY1, OW1 (this is a slight simplification of how stress is represented in the standard CMU pronunciation dictionary, but it the format we will be using here.)

Question 4: Create an FST that adds aspiration to transcriptions according to the rule above. The input alphabet is the set of symbols in the ARPABET. The output alphabet is the same, plus additional symbols as follows: each symbol that corresponds to a voiceless stop gets a duplicate with _h appended to

it. For example, the symbol T is in the output alphabet, and in addition, we also have the new symbol T_h in the output alphabet.

Step 1: Find the CMU dictionary ARPABET symbols that correspond to voiceless stops (consult the Ojeda book if needed, or the IPA chart).

Step 2: Add new symbols to create the output alphabet described above.

Step 3: Create a transducer that implements the phonological rule described above and produces outputs with the new symbols that reflect aspiration when appropriate. The input is the transcription as produced by a transducer like cmudict.pl from HW 1, but with the additional symbols used to denote stress (e.g. ay1, ow1, ey1), as shown above. The output should be the transcription with aspiration.

As always, to *create the transducer in prolog format*, we can make all of the symbols lowercase. For example, if our input is

```
[p, ah, t, ey1, t, ow]
```

the output should be

```
[p, ah, t_h, ey1, t, ow]
```

where the t_h is the aspirated allophone of t.

(This time it is fine if your transducer maps the input string to itself, in addition to the aspirated version. However, it is not fine if your transducer creates aspirated plosives where it should not.)

What to submit for Question 4:

- a. Add a picture of your FST diagram to your PDF submission.
- b. Submit your FST as a file in prolog format. Call it hw2q4.pl.

What to submit for HW3:

1. a PDF file with the answer to question 1 and pictures of FSTs for questions 2, 3 and 4 (call the file hw2.pdf).
2. a prolog file for question 2 called hw3q2.pl
3. a prolog file for question 3 called hw3q3.pl
4. a prolog file for question 4 called hw3q4.pl