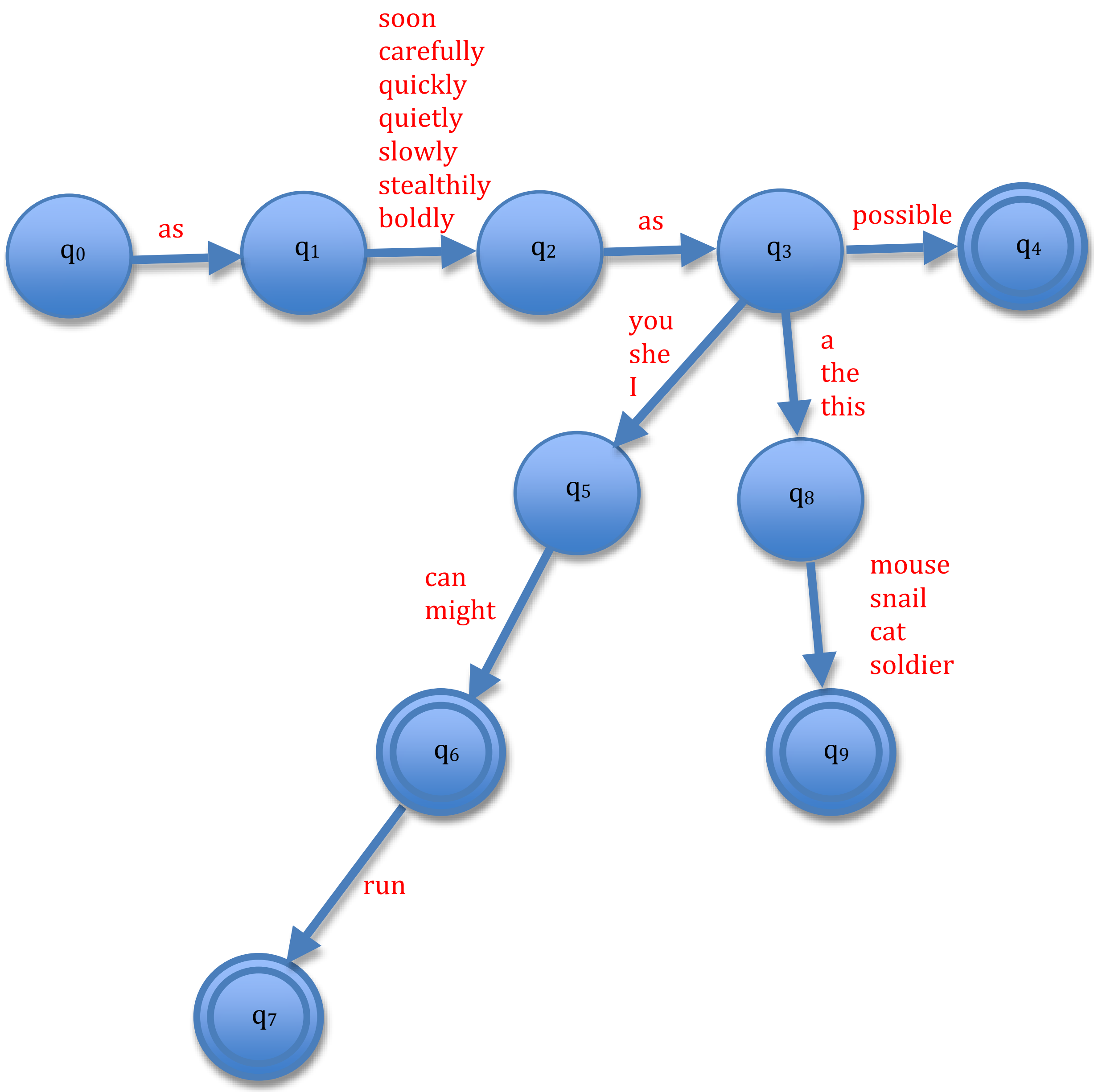
Name: ______________________________

ICS 661 Midterm

1. Write an FSA for the adverbial phrases: as soon as possible, as quietly as possible, as soon as you can, as carefully as I can, as quickly as she might run, as quietly as a mouse, as slowly as a snail, as stealthily as the cat, as boldly as this soldier. Also accept any similar syntactically correct adverbial phrases ignoring semantic constraints that use the above words such as: as slowly as a cat.



2. Given the following relative bigram probabilities, show and calculate the formula for the Perplexity of "Time flies like arrows."

	time	flies	like	arrows	</s>
<s>	0.01	0.003	0.0002	0.005	0
time	0.00003	0.02	0.006	0.0007	0.00001
flies	0.000002	0.000001	0.05	0.000001	0.007
like	0.03	0.007	0.000001	0.004	0.000002
arrows	0.00008	0.000002	0.08	0.000002	0.001

In the above table, P(flies | time) = 0.02

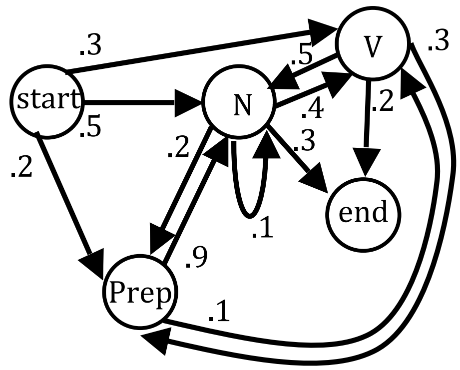
P("Time flies like arrows") =

$$\sqrt[5]{\frac{1}{P(time|\langle s\rangle)\cdot P(flies|time)\cdot P(like|flies)\cdot P(arrows|like)\cdot P(\langle /s\rangle|arrows)}}$$

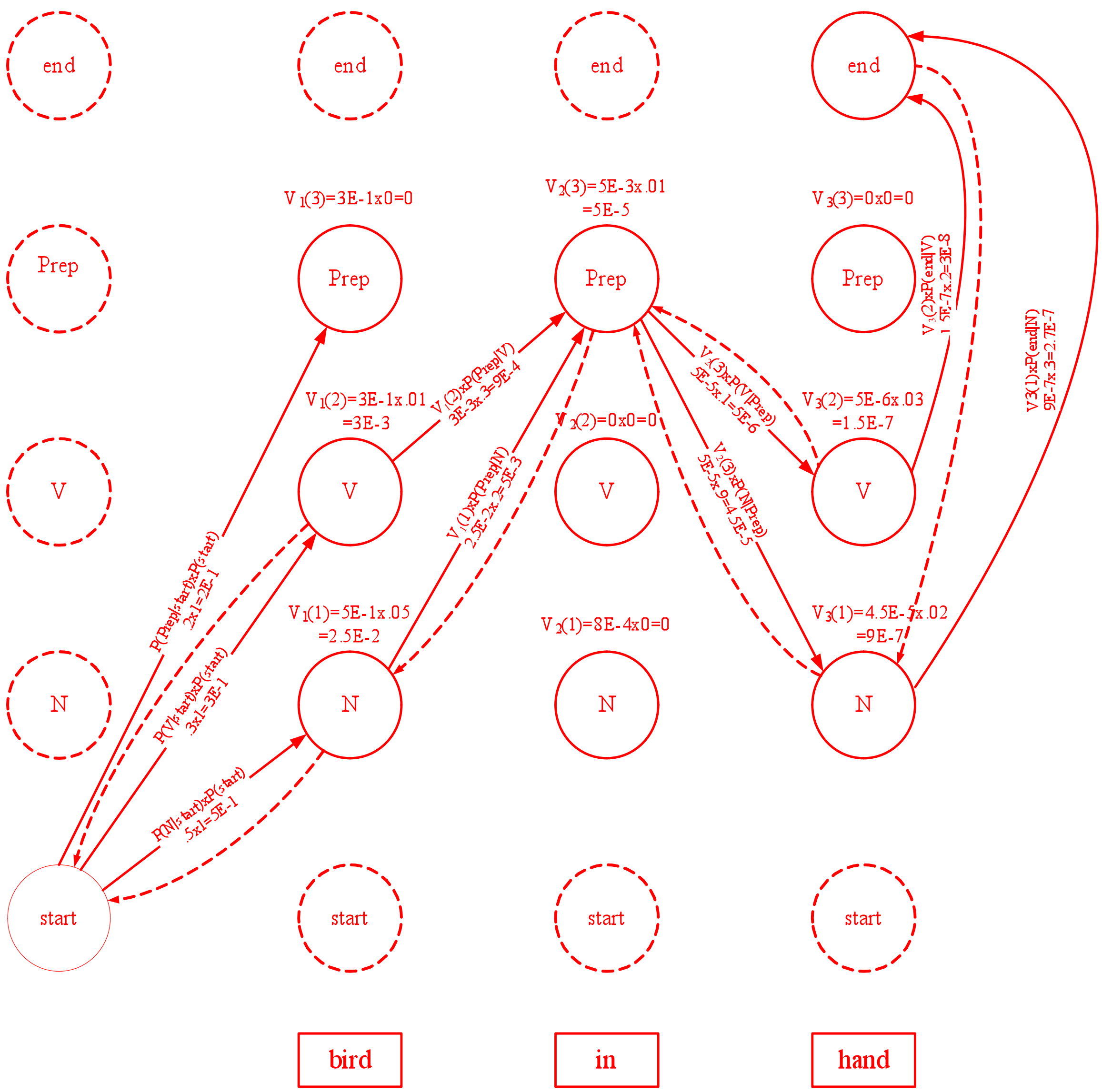
$$= \sqrt[5]{\frac{1}{0.01 \cdot 0.02 \cdot 0.05 \cdot 0.004 \cdot 0.001}}$$

= 120.11

3. Given the following HMM and the relevant observation likelihoods, show the Viterbi algorithm in action (the trellis) for “bird in hand.”



	bird	in	hand
Prep	0	0.01	0
N	0.05	0	0.02
V	0.01	0	0.03



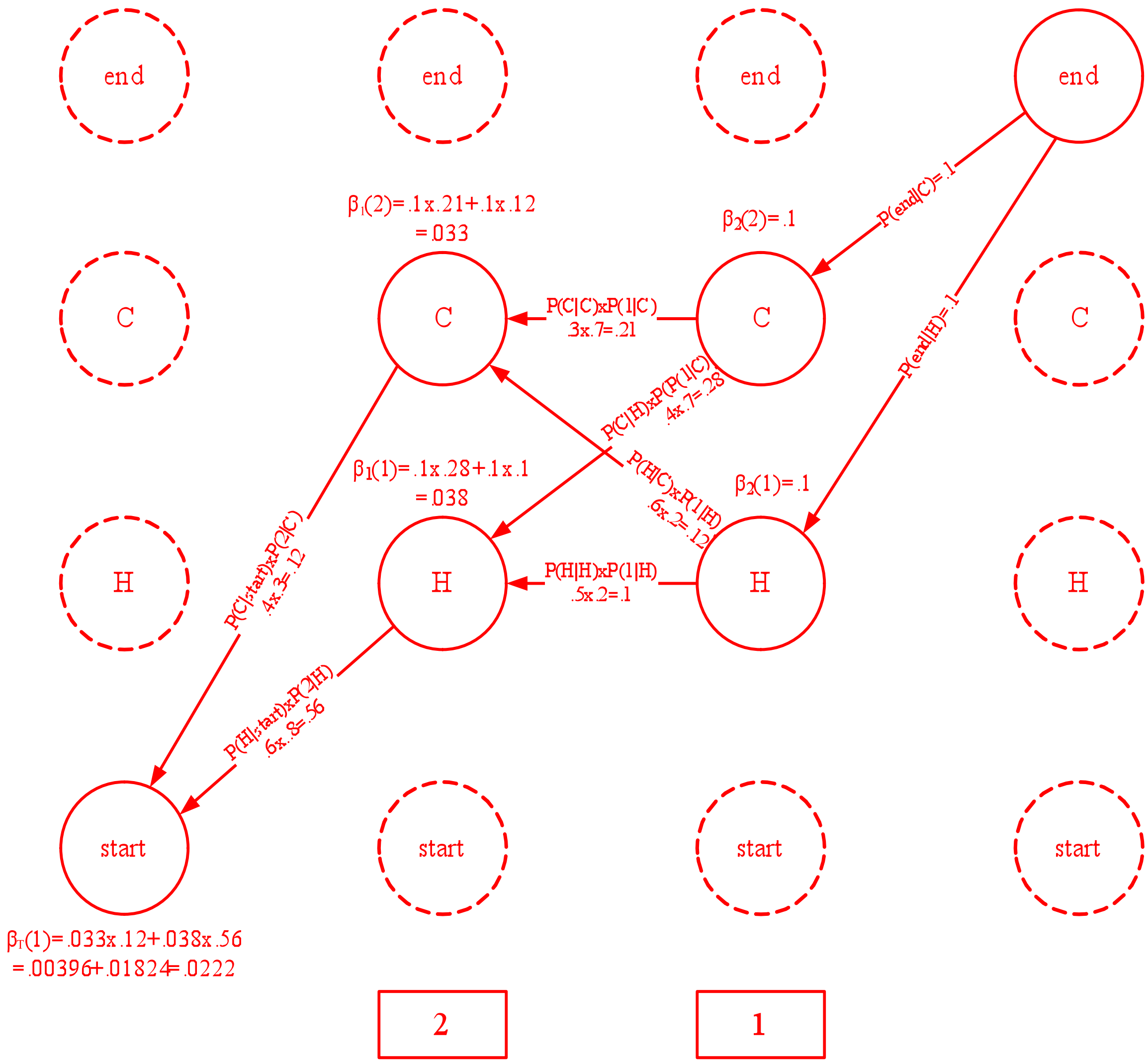
4. Assume an HMM with two states, Hot and Cold, begin to use the Forward-Backward algorithm to learn the new transition and emission probabilities after one iteration given the following initial probabilities:

Transition: Hot → Cold = 0.4 Hot → Hot = 0.5
Cold → Cold = 0.3 Cold → Hot = 0.6
Start → Cold = 0.4 Start → Hot = 0.6
Cold → Stop = 0.1 Hot → Stop = 0.1

Emission: P(1|Cold) = 0.7 P(2|Cold) = 0.3
P(1|Hot) = 0.2 P(2|Hot) = 0.8

And the following 2 training observations (number of ice creams eaten on each of two days, which can be either 1 or 2): 2 1

by showing the backward trellis (β) only:



5. Write a phrase-structured grammar and lexicon to match all of the following adjective phrases (AdjP). Your grammar should be as general as possible (i.e. it should be easy to add similar AdjP by adding more words to your lexicon) without being too general such that it will accept incorrect adjective phrases.

   big enough of a box, small enough of a company, fast enough of a shutter speed, pretty enough of a girl

   should not match: *big enough of the box, *big enough of any box

   AdjP → Adj enough of a Nominal
   Adj → big | small | fast | pretty
   Nominal → Noun Nominal
   Nominal → Noun
   Noun → box | company | shutter | speed | girl

6. Given the following grammar and lexicon, show the **top-down** parse chart for "Turn right here." Be sure to show all constituents and all partial matches. Be sure to label all constituents with a unique subscript and also specify their sub-constituents.

Grammar:	*Lexicon:*
S → VP	V → turn
VP → V	N → right
VP → V NP	Adv → right | here
VP → VP Adv	
NP → N	
Adv → Adv Adv	

<table>
<tr><td colspan="3">S_6 (VP_6)</td></tr>
<tr><td colspan="3">S_5 (VP_5)</td></tr>
<tr><td colspan="3">S_4 (VP_4)</td></tr>
<tr><td colspan="3">VP_6 (VP_2 Adv_2)</td></tr>
<tr><td colspan="3">VP_5 (VP_3 Adv_3)</td></tr>
<tr><td colspan="3">VP_4 (VP_2 Adv_2)</td></tr>
<tr><td></td><td colspan="2">Adv_3 (Adv_1 Adv_2)</td></tr>
<tr><td colspan="2">S_3 (VP_3)</td><td></td></tr>
<tr><td colspan="2">S_2 (VP_2)</td><td></td></tr>
<tr><td colspan="2">VP_3 (VP_1 Adv_1)</td><td></td></tr>
<tr><td colspan="2">VP_2 (V_1 NP_1)</td><td></td></tr>
<tr><td>S_1 (VP_1)</td><td>NP_1 (N_1)</td><td></td></tr>
<tr><td>VP_1 (V_1)</td><td>Adv_1 (right)</td><td></td></tr>
<tr><td>V_1 (turn)</td><td>N_1 (right)</td><td>Adv_2 (here)</td></tr>
<tr><td>Turn</td><td>right</td><td>here</td></tr>
</table>

0 1 2 3

[0, 1] VP → V_1 • NP

[0, 1] VP → VP_1 • Adv

[1, 2] Adv → Adv_1 • Adv

[2, 3] Adv → Adv_2 • Adv

[0, 2] VP → VP_2 • Adv

[0, 2] VP → VP_3 • Adv

[1, 3] Adv → Adv_3 • Adv

[0, 3] VP → VP_4 • Adv

[0, 3] VP → VP_5 • Adv

[0, 3] VP → VP_6 • Adv

[0, 0]: γ → • S
S → • VP
VP → • V
VP → • V NP
VP → • VP Adv

[1, 1]: NP → • N
Adv → • Adv Adv

[2, 2]: Adv → • Adv Adv

[3, 3]: Adv → • Adv Adv

7. Given the Probabilistic Context-Free Grammar below, show the probabilistic CKY parse table for "Turn right here."

S → V NP	.5	S → turn	.01
S → VP Adv	.3	V → turn	.2
VP → V NP	.4	NP → right	.04
VP → VP Adv	.1	Adv → right	.05
Adv → Adv Adv	.01	Adv → here	.03

S_1 (turn): .01 V_1 (turn): .2 [0, 1]	S_2: .5×.2×.04=.004 VP_1: .4×.2×.04=.0032 [0, 2]	S_3 (VP_1 Adv_2): .3×.0032×.03 = .0000288 VP_2 (VP_1 Adv_2): .1×.0032×.03 = .0000096 [0, 3]
	Adv_1 (right): .05 NP_1 (right): .04 [1, 2]	Adv_3 (Adv_1 Adv_2): .1×.05×.03=.000015 [1, 3]
		Adv_2 (here): .03 [2, 3]
Turn	right	here.