1. **(a)**



Emission probabilities:

* Cow
* P (moo | Cow) = 0.9
* P (hello | Cow) = 0.1
* Duck
* P (quack | Duck) = 0.6
* P (hello | Duck) = 0.4

**Step1: The first token is “moo”**

0 1 2 3 4

Start 1 0

0.09

Cow 0 0.9 \* 0.1

Duck 0 0 \* 0

End 0 0

**Step2: The second token is “hello”**

(If “moo” is from Cow state)

0 1 2 3 4

Start 1 0 0

0.09 0.0045

Cow 0 0.9 \* 0.1 0.09\*0.1\*0.5

0.0108

Duck 0 0 \* 0 0.09\*0.4\*0.3

End 0 0 0

(If “moo” is from Duck state)

0 1 2 3 4

Start 1 0 0

0.09 0.0045

Cow 0 0.9 \* 0.1 0\*0.1\*0.5=0

0.0108

Duck 0 0 \* 0 0\*0.4\*0.3=0

End 0 0 0

“hello” take maximum, set back pointers,

0 1 2 3 4

Start 1 0 0

0.09 0.0045

Cow 0 0.9 \* 0.1 ~~0\*0.1\*0.5=0~~

0.0108

Duck 0 0 \* 0 ~~0\*0.4\*0.3=0~~

End 0 0 0

**Step3: The third token is “quack”**

(If “hello” is from Cow state)

0 1 2 3 4

Start 1 0 0 0

0.09 0.0045 0

Cow 0 0.9 \* 0.1 ~~0\*0.1\*0.5=0~~ 0.0045\*0\*0.5

0.0108 0.00081

Duck 0 0 \* 0 ~~0\*0.4\*0.3=0~~ 0.0045\*0.6\*0.3

End 0 0 0

(If “hello” is from Duck state)

0 1 2 3 4

Start 1 0 0 0

0.09 0.0045 0

Cow 0 0.9 \* 0.1 ~~0\*0.1\*0.5=0~~ 0.0108\*0\*0.3=0

0.0108 0.00081

Duck 0 0 \* 0 ~~0\*0.4\*0.3=0~~ 0.0108\*0.6\*0.5=0.00324

End 0 0 0

“quack” take maximum, set back pointers

0 1 2 3 4

Start 1 0 0 0

0.09 0.0045 ~~0~~

Cow 0 0.9 \* 0.1 ~~0\*0.1\*0.5=0~~ 0.0108\*0\*0.3=0

0.0108 ~~0.00081~~

Duck 0 0 \* 0 ~~0\*0.4\*0.3=0~~ 0.0108\*0.6\*0.5=0.00324

End 0 0 0

**Step4: End state**

(If “quack” is from Cow state)

0 1 2 3 4

Start 1 0 0 0

Cow 0 0.09 0.0045 0

Duck 0 0 \* 0 0.0108 0.00324

End 0 0 0 - 0\*0.2 = 0

(If “quack” is from Duck state)

End takes maximum, set back pointers

0 1 2 3 4

Start 1 0 0 0 -

Cow 0 0.09 0.0045 0 -

Duck 0 0 \* 0 0.0108 0.00324 -

~~0\*0.2 = 0~~

End 0 0 0 - .00324\*.2=.000648

**Decode:**

moo = Cow, hello = Duck, quack = Duck

So the probability of emitting this sentence from this state sequence is 0.000648.

0 1 2 3 4

Start 1 0 0 0 -

Cow 0 0.09 0.0045 0 -

Duck 0 0 \* 0 0.0108 0.00324 -

End 0 0 0 - 0. 000648

**(b)** There is another state sequence:

moo = Cow, hello =Cow, quack =Duck.

The probability is 0.000162

0 1 2 3 4

Start 1 0 0 0 -

Cow 0 0.09 0.0045 0.0045\*0\*0.5=0 -

0.00081

Duck 0 0 \* 0 0.0108 0.0045\*0.6\*0.3

End 0 0 0 .00081\*.2=.000162