VINA NGUYEN: OK. So do you guys understand what's going on? All right. OK. So there's bacteria here, and then a duplication process. They can either duplicate or die. And that's just for one bacteria. So you have 2, then that one remains unchanged. Does that make sense? OK.

So Question 1 was, what does assumption two mean, in terms of percentages? What's the probability that a cell will duplicate, and what's the probability that the cell will die?

AUDIENCE: [INAUDIBLE]

VINA NGUYEN: Louder.

AUDIENCE: What?

VINA NGUYEN: Louder.

AUDIENCE: It's 50/50.

VINA NGUYEN: Yeah. So 1/2, right? So this is one half. That's all that question is asking.

AUDIENCE: Actually 0. Or if you're at 4 [INAUDIBLE].

VINA NGUYEN: Yes. But this is just for assuming an initial state of 1. OK. Anyone for Question 2? Give me an example of a chain where the bacteria neither regions n equals 0 or n equals 4.

AUDIENCE: It succeeds, then it fails. It succeeds, then it fails. It succeeds, then it fails forever.

VINA NGUYEN: What?

AUDIENCE: It succeeds, then fails forever. It succeeds, fails, succeeds, fails.

VINA NGUYEN: Yeah. So an example of a chain would be right. Yeah. It can also go from 1, 2, 3, 2, 1, et cetera, et cetera. OK. So that's pretty easy. This path, right here, is called a trajectory in terminology. And attainable, If you guys read that, means that you can reach a certain state from another state. So we can reach state 3 from state 1. You can't reach states 3 from state zero. So that means unattainable. You can't have bacteria that's non-existential.

OK. So for question three, did anybody have five generations?

AUDIENCE: Yeah. 2, 3, 2, 1, 0.

VINA NGUYEN: OK. Anyone for 4?

AUDIENCE: Isn't that impossible?

VINA NGUYEN: Yeah. So it's not possible. So you need to make sure you get your problem space correct, because some paths cannot exist, and some can. So that's the important part of defining your model. And if these aren't clear to you, then you need to redefine the model. OK?

All right, so Question 4. I know a lot of you guys asked. It's my fault. Transition probabilities are the probabilities that you can reach a state to another state in just one step. Yeah. So if I give you-- this is a transition probability.

So this is telling you the probability that you go from state I to state J. And I or J can-- which is what n was-- can be either state 0, 1, 2, 3, or 4. So what I am asking you is the probability that you go from state 0 to state 0 is-- or the probability that you go from state 1 to 0, or the probability that you go from 1 to 2-- something like that.

So for these transition probabilities, can anyone tell me what this is?

AUDIENCE: 1.

VINA NGUYEN: Yeah.

AUDIENCE: Or we could just look at this.

VINA NGUYEN: Yeah, I know. This one?

AUDIENCE: Yeah, I can't read the numbers.

VINA NGUYEN: Oh.

AUDIENCE: Can't see that far.

VINA NGUYEN: 1, 0, 1/2. Yeah. 1 to 2 is 1/2, right? And then 4 to 4 is unrealistic, but for is problem it's going to be 1. OK? So that's what it's asking you. Question 5 is more of a [? thought ?] answer. So did you guys read beforehand the concepts, how that affects it? OK.

AUDIENCE: Wait, what's the difference between the two concepts?

VINA NGUYEN: Right. [INAUDIBLE] OK. So the first one is referring to not the actual states, but more like your actual problem-- so how the bacteria actually changes, if that affects your problem.

AUDIENCE: Oh.

VINA NGUYEN: But the second one is just based on the number, which is [? your state. ?] So for this model to work, if you're at state 3, then it doesn't matter what states you're at before 3. What only matters is that you're at state 3 right now. OK. So does that make sense?

AUDIENCE: Yeah.

VINA NGUYEN: OK.

AUDIENCE: So that would be number two.

VINA NGUYEN: Mm-hmm. And that's called the Markov property. OK. So did you guys figure out 6 at all?

AUDIENCE: What was Question 6?

VINA NGUYEN: So transition probabilities are going from one state to the next in one step, right? But now I'm asking, what are the probabilities? Two steps. So I would do 6, 7, and 8 at once, then, because those answer better using matrices.

You guys have this diagram already, right? It's not labelled, but it's the fourth figure. You guys have this, right? OK, so this is just for one step. But did anyone figure out how to get this matrix for two steps? Yeah.

AUDIENCE: [INAUDIBLE] you got the same thing that I got when I actually did it at home.

VINA NGUYEN: So you mean multiply it by itself?

AUDIENCE: Yeah.

VINA NGUYEN: Yeah. So that would get you the second. So I'll just do that [INAUDIBLE].

AUDIENCE: [INAUDIBLE]

VINA NGUYEN: No, I'm OK.

AUDIENCE: Oh, it's an eraser.

VINA NGUYEN: You got an eraser over there? OK. I'll just do it here. OK. So you guys-- hm?

AUDIENCE: There's one right there, behind it.

VINA NGUYEN: In this one? It's just--

AUDIENCE: No, no. Yeah. Push that one, the one you're holding.

VINA NGUYEN: Yeah, I used to have three. Oh, here it is. OK. So quick review if you guys don't know how to do matrix multiplication. You already know?

AUDIENCE: No.

VINA NGUYEN: No? OK, I'll just go over it. OK, so for you guys who do know, what's this?

AUDIENCE: ab equals [INAUDIBLE].

VINA NGUYEN: Right? Does that make sense? This row, this column, this row, this column. Right? So aa-- aa, bc, ab, dd. Right? OK. So which one is this?

AUDIENCE: [INAUDIBLE]

VINA NGUYEN: d. OK. Everyone get that? You'll get it more as you see numbers. OK. So we have, for our case , b00, b11, et cetera, et cetera. So if you multiply it out together, then what do you get? You get p00 times p00, right? Can anyone tell me that? What's next? Right?

Yeah, I'm just going to do the first two-- the first two entries. So you can just multiply it, but you need to understand why that works. So this tells you how it works, because it goes from 0 to 0, 0 back to 0, which is what you want in two steps. And then this is 0 to 1, and back to 1 to 0, just two steps again. Right? Same thing for two-- 0 to 2, 2 to 0, et cetera.

And the second entry the same way, so that you have a different initial state. So 1 to 0, 0 to1. Or wait-- 00. Does that make sense to everybody? OK. So if you just follow that same formula, you'll get it for every initial state and every end state in two steps. And the easy way to do that is to just multiply the matrix-- so what you see.

So pn means this transition probably matrix for one step times the number of steps. So to get the number two steps, you would just times it by itself. Three steps, you just times it by itself. [INAUDIBLE] So does anyone have a calculator? Do you? OK.

AUDIENCE: [INAUDIBLE] matrix with two steps?

VINA NGUYEN: OK. The question I want to answer, though, is if any of those values converge if n is large. So if you multiply your matrix a million times, does it converge? Do these numbers converge?

AUDIENCE: [INAUDIBLE]

VINA NGUYEN: Hm?

AUDIENCE: [INAUDIBLE]

VINA NGUYEN: OK.

AUDIENCE: Well, I think it will eventually go to either 0 or 4.

Well, I have the 5 by 5. [INAUDIBLE]

The probability would be the 3, 2 and you'd have the trajectory go on forever. [INAUDIBLE] that should be 0. And then all you'd have to do is [INAUDIBLE] you should have 3/4 and 1. [INAUDIBLE].

VINA NGUYEN: So you're getting there. The matrix will tell you for every single possible step-- every initial state, every end state. So if I asked you--

AUDIENCE: [INAUDIBLE]

VINA NGUYEN: Well if I asked you the probability that you can go from state two to four with n-- or two to three with n equals forever, then that's a little harder, right? So then you have to multiply all the different combinations.

AUDIENCE: [INAUDIBLE] say, hey, this is the thing that failed completely in this number set [INAUDIBLE]

VINA NGUYEN: You know, you might be right. And I would have to read more, but for now, we're just doing it this way. But I can get back to you.

AUDIENCE: [INAUDIBLE]

VINA NGUYEN: Did you get it yet?

AUDIENCE: Well, how many times do you want me to [INAUDIBLE]?

VINA NGUYEN: Just until the values converge.

AUDIENCE: Until they converge? [INAUDIBLE]

VINA NGUYEN: Because n is relative.

AUDIENCE: Do I need to know how many times?

VINA NGUYEN: Well, it would be nice.

AUDIENCE: Whoops.

VINA NGUYEN: It's OK.

AUDIENCE: [INAUDIBLE]

VINA NGUYEN: That's fine.

AUDIENCE: I'm just pressing the enter button and seeing--

VINA NGUYEN: It's OK. Converge means the values stop chaining.

AUDIENCE: OK, what is values?

VINA NGUYEN: Any-- all the values in the matrix.

AUDIENCE: The first column stopped.

VINA NGUYEN: Right. How about the rest?

AUDIENCE: Not yet.

VINA NGUYEN: Not yet? OK. And you can do it to two decimal points. That's fine.

AUDIENCE: What's weird is in the second column, the numbers get fluctuated.

VINA NGUYEN: Second column?

AUDIENCE: Yeah.

VINA NGUYEN: That means they don't converge.

AUDIENCE: Cool. So yeah, they don't converge. But the first column-- wait, let me check the third column.

Oh, wait. No, they do. It's just getting close to 0. I didn't see the negative 0.9.

VINA NGUYEN: OK. Then they do.

AUDIENCE: Yeah, sorry.

VINA NGUYEN: No, it's fine.

AUDIENCE: Whoops.

VINA NGUYEN: Oh, you're right, because it's e to the--

AUDIENCE: Yeah. I didn't see that [INAUDIBLE].

AUDIENCE: Hey, look at the [INAUDIBLE].

VINA NGUYEN: OK. So you do have a value?

AUDIENCE: Yeah.

VINA NGUYEN: OK. So what's your matrix?

AUDIENCE: OK, this is going to take a while. [INAUDIBLE]. OK, 1, 0, 0, 0--

VINA NGUYEN: You can go by column.

AUDIENCE: Oh.

VINA NGUYEN: It might be-- yeah.

AUDIENCE: OK. 1.75, 0.5, 0.25, and 0. And then 0-- these are basically 0s all the way down. And then 0s all the way down. Well, 0, 0, 1, 0, 0.

VINA NGUYEN: This one?

AUDIENCE: Yeah, I think so. Wait.

VINA NGUYEN: No, this is 0.

AUDIENCE: That's new. And then all 0s again. And the last one's just the first one reversed. So 0, 0.25, 0.5, 0.75, 1.

VINA NGUYEN: All right. So does everyone see what this is saying? Basically, if you repeat this experiment for n equals forever, or some really large number, then you can figure out a probability for this entire model. Then you can go from state 0 to 0, state 1 to 0, state 4 to 4, or state 3 to 4, et cetera.

So from your initial problem, you only know that it's half, half, half. And you have no idea, really, how the experiment is going to end up in the long run. But if you do this thing you can see, oh, well if I start off with three, then I have a greater chance ending on 4. [INAUDIBLE] a 75% chance of getting to n.

But if I start, like, initial state 1, the I have, in the long run, 75% chance of dying out. So this tells you all the possibilities that can happen if you run it over and over and over. Does that make sense? So the important thing to notice is that your initial state does matter in how it ends up, even if the probabilities seem pretty much the same initially.

OK. So that's Question 9, I thin. Yeah. So a Markov model is illustrated usually in this way. So you have the states like this. And then you'll draw arrows that represent the probabilities. So 0 goes back to 0 probability of 1. And then 1, 2, 0 is 1/2. 1 to 2 is 1/2, et cetera.

So this is a new way of describing your problem space, right? This is what's going on in your entire model. Because unlike before where we had specific outcomes-- you could figure out the probability of each-- this one keeps alternating. So that's basically what it's trying to tell you. OK?

And if you guys did read it, right here I think it tells you that state 0 and 4 are called absorbing states because that's where ultimately your experiment will end up. So they're like endpoints for this model. OK? So does that make sense, everybody? So Number 1, did anyone get an answer?

AUDIENCE: [INAUDIBLE]

VINA NGUYEN: Yeah?

AUDIENCE: 10%?

VINA NGUYEN: Yeah. Did everyone get that?

AUDIENCE: Yeah.

VINA NGUYEN: Everyone understand it?

AUDIENCE: Yeah.

VINA NGUYEN: Anyone want me to go over it?

AUDIENCE: No.

VINA NGUYEN: OK. So that's an easy-- OK. 2?

AUDIENCE: [INAUDIBLE]

VINA NGUYEN: Can you give me in fractions?

AUDIENCE: 95 times 94 times 96 times 92 over 100 times 99 times 98 times 97.

VINA NGUYEN: Did everyone get that? So-- right? Because there is 95 [INAUDIBLE]. And then every time you choose one, you have to take one out. OK? Does that make sense to everybody? So is that hard? Easy? Medium?

AUDIENCE: Wait. Shouldn't there be one-- oh, but that was just [INAUDIBLE]. Never mind. I counted wrong.

VINA NGUYEN: Is this harder than the last one?

AUDIENCE: Yep.

VINA NGUYEN: A little harder?

AUDIENCE: Just that one was easy.

VINA NGUYEN: Just curious. 3? Anyone got an answer?

AUDIENCE: 2/3?

VINA NGUYEN: Yeah. Did you get that too? OK. Well, I'll go over it, then. All right, so there's four combinations of kids, right? You get it now? OK. So if they have a boy, it can be this. And there's 2/3 chance that he has it.

AUDIENCE: [INAUDIBLE] 2/3 [INAUDIBLE] has the same thing? Like, [INAUDIBLE]?

VINA NGUYEN: Oh, OK. Yeah. So it's different, yeah-- because it matters which order he can--

AUDIENCE: Well, it's still really confusing because it's about meeting the boys. In the third example, you wouldn't have met the boy.

AUDIENCE: Why not? Well, they're both boys, and they're both alive. So you could have met either one. Doesn't matter if they're older or younger.

AUDIENCE: Yes, but with those two, then you have the same chance of meeting a girl. Like, with both of them, you have 3% chance that--

VINA NGUYEN: But there's no chance whether you meet either one, because I'm telling you you are meeting a boy.

AUDIENCE: Right.

VINA NGUYEN: Yeah. So it's an assumption, right?

AUDIENCE: [INAUDIBLE]. I don't know.

AUDIENCE: Is someone's cell phone going, or is that just another room?

AUDIENCE: No, that's the other room. They're playing Cindy Lauper.

AUDIENCE: Where is this other room?

VINA NGUYEN: That's odd. 4?

AUDIENCE: 45?

AUDIENCE: 45%. 0.45.

VINA NGUYEN: Oh, I didn't calculate it, so I thought you did the-- the way to do it.

AUDIENCE: 0.3 times 0.5.

VINA NGUYEN: OK.

AUDIENCE: Plus 0.4 times 0.25 plus 0.8 times 0.5.

VINA NGUYEN: So what is that? What did you say?

AUDIENCE: 0.45.

VINA NGUYEN: OK. All right. So you shouldn't play, because you'll lose. Yeah?

AUDIENCE: 8 times 70,000.

VINA NGUYEN: Oh, sorry. I-- OK, yeah.

AUDIENCE: No, it's 8 million.

VINA NGUYEN: Everyone understand this? So you only have 8 options for your first digit. And then for the rest, you have 10 options.

AUDIENCE: Oh, congrats. 0. Yay!

VINA NGUYEN: Does that make sense? I forgot to ask. So 3-- easy, medium, hard? Medium?

AUDIENCE: Medium.

Yeah, medium.

Hard.

VINA NGUYEN: Hard. OK. How about 4?

AUDIENCE: Easy.

VINA NGUYEN: 5?

AUDIENCE: Easy.

VINA NGUYEN: So for 6, did anyone get that?

AUDIENCE: Hard.

VINA NGUYEN: So pmf is basically the probability that your random variable can be [INAUDIBLE]. And I'll kind of explain that. And I'll upload the file so you can look at it. Did anyone get 6?

AUDIENCE: [INAUDIBLE]

VINA NGUYEN: Probability math's not good. OK, so this is--

AUDIENCE: This is hard?

VINA NGUYEN: This is hard. OK. I see. Do you remember this one? I know you have.

AUDIENCE: Oh. Kind of, yeah.

AUDIENCE: [INAUDIBLE]

VINA NGUYEN: This is binomial, right? OK, yeah. OK, good. So to answer your question, since you weren't here, k is the different numbers that your [? random interval ?] can take, right? And this the probability that you get that. So is this just a formula for saying what you're probability would be. So if I give you this, would that be a little easier? You can figure out what n is, what k is.

AUDIENCE: Wait, k is 0.01-- no, p is 0.01, right?

VINA NGUYEN: Yeah. So p is 0.01.

AUDIENCE: I'm assuming n is 1,000 because n minus [? 10 ?] needs to be positive.

VINA NGUYEN: Mm-hmm.

AUDIENCE: So then [INAUDIBLE].

VINA NGUYEN: So k equals [? n0 ?] to--

AUDIENCE: 49?

VINA NGUYEN: Yeah.

AUDIENCE: Wait. Wouldn't it be 1 to 50?

VINA NGUYEN: I think. I have to double check that. I think it's right. So-- OK, let me read this again. So you have 50 modems for 1,000 customers, but you can't have a k greater than 50, because you only have 50, right?

AUDIENCE: Yeah.

VINA NGUYEN: So that answers your question.

AUDIENCE: So why can't you have 0?

AUDIENCE: Because 0 isn't [INAUDIBLE]. Wait, which modem would be labeled number 0? It says there are 50 modems, so it would just be 1 to 50.

AUDIENCE: Yeah, but you could be using none of the modems.

VINA NGUYEN: Yeah, you're right. So you can-- like, maybe none of the customers need it.

AUDIENCE: Oh.

VINA NGUYEN: Yeah, yeah. You're right. Thank you. So it can go from 0 to 50. And then n is 1,000, because that's the total number of customers. OK, so that would be-- OK? So does that makes sense? If I give you this, is that easier?

AUDIENCE: Yes.

VINA NGUYEN: OK, so it's hard. OK. Do you guys understand? Any other questions?