[SQUEAKING]

[RUSTLING]

[CLICKING]

MICHAEL SCOTT ASATO CUTHBERT: Let's get started. Welcome back. 21M. 383, Computational Music Theory and Analysis. We went through probably one of the most slide-heavy, one of the fastest classes ever on Wednesday that I'll be doing this semester. Today, we're going to switch gears. We're going to do one of the least tech-heavy classes in this semester, and then we'll probably keep going back and forth. This is the only one that in my particular notes, it's for my lecture. It says, Mike, don't panic. There actually is no PowerPoint, because I was panicking the other day when I was preparing this. I was like, wait, wait, wait wait. Did I delete it?

No, there is nothing, because I want us to step back for a little bit and think about some of the things and do some work on some of the things to do with what we mean by music, because various musical points. Because there's a lot of things that we can know that are just sort of intuitively, we all know what that is. But then we might not be able to explain it to a computer, because computers are smart or computers are dumb. What do you think? Shout it out.

AUDIENCE: Dumb.

AUDIENCE: Neither?

MICHAEL SCOTT ASATO CUTHBERT: Neither, dumb, neither. No, no smart? OK, I think computers are really, really dumb until we make them smart or something like that. Great. There's some people in the back whose names I don't know. Could you take a sheet of paper? You can also use your outline to put your name on it, because-- the outlines for reading later. And it's kind of nice this way you have it for later. And this way, you won't sort of get me if I go out of order, right?

OK. So I'm seeing here your names are. Can you take a second and at least the person you're sharing a table or sharing the invisible table with, and introduce yourself if you don't know them?

[SIDE CONVERSATION]

MICHAEL SCOTT ASATO CUTHBERT: OK, now add into your conversation what you think a note is. You can also keep getting to know each other at the same time. But what you think a note is?

[SIDE CONVERSATION]

AUDIENCE:

Yeah.

MICHAEL SCOTT ASATO CUTHBERT: OK, I'm going to be asking you for some definitions in a second. But before we get to that, all I want you to do is take your definitions-- you've kind of got them the first thing-- and you've just got to count notes, OK? So I'm going to sing some things, and you tell me how many notes I sing. So write them down, and then I'll ask them later. First set.

[SCAT SINGING]

Pretty easy, right? Second one.

[SCAT SINGING]

Third one.

[SCAT SINGING]

Fourth one.

[SCAT SINGING]

And fifth one.

[CLAPS]

[MELODY PLAYING]

Great. Talk with your neighbor and see if you got answers that line up with each other. OK, let's come back together.

AUDIENCE:

Yeah, [INAUDIBLE].

MICHAEL SCOTT ASATO CUTHBERT: Let's come back together. We have-- I believe that the normal distribution of names in this class is kind of like the letters in the alphabet. So we'll start with J's. I'll call on-- who's the alphabetically first J? Is it Jason? Jason, something like-- and if I change the things, I'm doing it accidentally because I don't remember what I sang, but the first one--

[SCAT SINGING]

AUDIENCE: Three notes?

MICHAEL SCOTT ASATO CUTHBERT: Three notes. How many agree? How many disagree? Agrees? Disagrees? OK, good. That was the right answer. I sang three notes. Good. Who's alphabetically next after Jason? We have Jonathans, Jordans. We have Jake. Oh, OK, we went out of order. Sorry about that, Jake. No, even if we do Jacob or something, I'm still wrong. OK, Jake? This is what I was saying.

[SCAT SINGING]

AUDIENCE: Probably one more.

MICHAEL SCOTT ASATO CUTHBERT: One note. Agree or disagree? Who agrees? Who disagrees? Good, everybody is wrong. I sang four. OK, next note. What's the next one I did? I went up, right?

[SCAT SINGING]

Next up alphabetically would be Jonathan comes before John and comes before Jordan. So Jonathan.

AUDIENCE: OK. My impression was two notes.

MICHAEL SCOTT ASATO CUTHBERT: Two notes. Good. Who agrees? OK, we got some agrees. Who disagrees? OK, good. Well, we'll continue with the J's on that. John, you disagreed. What's the number that you came up with?

AUDIENCE: I thought because you sang a lot, I think you sang at least one note.

MICHAEL SCOTT ASATO CUTHBERT: Oh, no. OK, OK. Whoa, whoa, whoa!

[LAUGHTER]

Greater than one note. No, greater than or equal to one note, right? OK, so that takes a little-- that's a pretty broad spectrum, I like that. It's always good. Who agrees with greater than or equal to one note or wants more-- disagree if you want more specificity than that. Who agrees with greater than or equal to one note? Good. Jordan's on your side. And she's got some people. Good. So who disagrees with everything beforehand up till now? Great. So I think we have-- now, Jason, we've already gone through. Raise your hands again if you disagree. I want to keep going alphabetically next among the disagreers. And that might be a Karima. Karima?

AUDIENCE: Yeah.

MICHAEL SCOTT ASATO CUTHBERT: Yep.

AUDIENCE: I wrote NASATO

MICHAEL SCOTT ASATO CUTHBERT: NASATO OK. We'll make it so that it parses in Python. Not a number. Is that OK? OK, good. Good. And anybody still have your number not said? Adam?

AUDIENCE: Yeah. I said 14 or 15.

MICHAEL SCOTT ASATO CUTHBERT: 14 or 15. OK, very, very specific. What do you base that on?

AUDIENCE: So you went from a C to either a C sharp or a D. So it's like if you go to all the chromatic notes and slur them all that's what you get.

MICHAEL SCOTT ASATO CUTHBERT: OK. OK, good. So we have a range extension. Good. Anybody else have a number that hasn't been done yet? So that's particularly good. This one, I went with inf. Oh, sorry, I wasn't telling you what my numbers were yet. OK. Well, that's one I went with. And then next one.

[SCAT SINGING]

We have some other-- [INAUDIBLE] we have a listener. But do you want to be a participant or also? Yeah, go ahead. So with that one.

AUDIENCE: I wrote 6.

MICHAEL SCOTT ASATO CUTHBERT: 6. Anybody agree? Yep. Anybody disagree? Good. OK. And yep. And now, oh you know I was giving the right numbers. Yep, so I'm going to say, I did that. I did that. Nobody disagreed? The correct answer there was 2. And don't worry, don't worry. This is not frustrating-- be frustrated. And then who's also around K? Or do I hear L? Oh. L?

AUDIENCE: 0.

MICHAEL SCOTT ASATO CUTHBERT: 0. Anybody disagree? Great. A person who's disagreed, who has to speak?

AUDIENCE: I just had 1.

MICHAEL SCOTT ASATO CUTHBERT: 1? Good. Who agrees with 1? Good. How many people have heard neither 0 nor 1?

AUDIENCE: Yep. So when I was writing a lot of these, I put two answers to a lot of them, depending on how--

MICHAEL SCOTT ASATO CUTHBERT: Yeah, OK, but you can only give one right now.

AUDIENCE: Yeah, well, it's how I notated, how I'd like pitch-wise, and I was taking it that--

MICHAEL SCOTT ASATO CUTHBERT: Oh.

AUDIENCE: I was like I was taking perception of specklegrams and a clap has all of the--

MICHAEL SCOTT ASATO CUTHBERT: Uh-huh. So give me a number.

AUDIENCE: That one would also be inf

MICHAEL SCOTT ASATO CUTHBERT: Inf. OK. Good. This one, I'm going to go with 0. And I will tell you there isn't a single answer on here that you couldn't argue for and be correct. So why three notes? I think we all agreed because I think I sang--

[SCAT SINGING]

And I count each of those as one note, right? Second one was 4, because--

[SCAT SINGING]

--was a whole note tied to a quarter note tied to a 16th note tied to a 64th note. And I do believe that is the closest shortest representation I can do notationally. So I was thinking in a notational sphere here. This time, with the glissando, I was thinking of it as an infinite number of notes, because if it's continuous, it could be. But on the other hand, any of these other ones could be correct. Now, let's see if anyone can come up with how from--

[SCAT SINGING]

--I came up with two.

AUDIENCE:

Two Pitches?

MICHAEL SCOTT ASATO CUTHBERT: There are two different pitches. That's one good way to do it. I'm glad I hit the same pitch each time, maybe something close. That's not the reason why I was thinking. Yeah.

AUDIENCE:

It's like sort of tremolo.

MICHAEL SCOTT ASATO CUTHBERT: Tremolo. Yeah. It was something like, I don't know. Well, I don't know what thing we're in. But yeah, I was thinking it as something like that. Or actually, it would be measured tremolo. Wouldn't it be like-- anyone know this sign, where you have a beamed or no? Just one beam, right? Two-beamed dotted half notes. You see it everywhere every once in a while when you're playing like Prokofiev or Schubert or something. I always like, oh, I have to remember what that is.

But that means fill in the space of one dotted half note with as many eighth notes as it takes to fill it in, alternating between the top one and the bottom one.

AUDIENCE:

And clap.

MICHAEL SCOTT ASATO CUTHBERT: And clap.

AUDIENCE:

[CLAPS]

MICHAEL SCOTT ASATO CUTHBERT: I thought a note to me had to have some sort of specifiable pitch. So I count zero. Now everything that somebody said, a one for this, or infinite, are all valid definitions of what we're going to be talking about. And here's the thing. 99% of the time when I'm not trying to set up an example for having fun in the first week of class with you all, there's no way I would call that second one four notes, right? I mean, if I hear it, I'm going to beat one.

So one of the things that's going to come up quite often is that depending on what purpose you want to do with something, you're not going to be able to necessarily even know how many notes or how many of something there is, let alone what's the correct spelling of something or not. So I think we're just going to be playing around with something like this. Now, go back to your definitions of notes that you had before, and let's grab into groups of four. So your two groups that are the same joining with the group behind you. So we're going to get good at spinning over here.

OK, a group of three here, and three here. And we'll break up this group. And talk about what your definitions of the notes were with the other group. And then try to figure out, A, if you had correct definitions or if you had compatible-- is not a correct definition, compatible definitions of notes before that with each other's group. And then also, if you want to change the definition based on all the weird numbers that we came up with here. So go ahead and let's take a couple of minutes to do that.

Great. Let's all come back together, and--

[SIDE CONVERSATION]

There was one word that I just kept hearing as I was going around, and it begins like this. When any group use a word that begins with this in their definition. Yeah. John, go ahead.

AUDIENCE: Representation.

MICHAEL SCOTT ASATO CUTHBERT: Representation, yeah. Presentation. So we can start with a note is a-- of-- is anybody's definition completely incompatible with this opening? Like, couldn't be put in-- it's no smiles, I think. OK, so what are some of the ways that your groups could have done this? I didn't think I heard, because it's physically difficult, what Jonathan, Karima, Jordan, and Misha's group came up with. How would somebody in this group continue that of everybody has-- oh, you guys are all normally distributed names. So I've heard from everybody. So Karima, would you like to--

AUDIENCE: I think that's anything with a pitch and duration.

MICHAEL SCOTT ASATO CUTHBERT: It's a representation of anything with a pitch and duration. And groups disagree with that? Yeah.

AUDIENCE: So I'm coming at this from the percussion perspective, where a note doesn't necessarily need a pitch, and it doesn't necessarily need a duration.

MICHAEL SCOTT ASATO CUTHBERT: OK. So we have not necessarily on that. So do you have a positive-- did your group come up with a positive definition from that?

AUDIENCE: I don't think our group came into agreement [INAUDIBLE]--

MICHAEL SCOTT ASATO CUTHBERT: Oh, good. Let's hear some--

AUDIENCE: --of you is a note as a representation of an instance of striking something.

MICHAEL SCOTT ASATO CUTHBERT: An instance of striking something. OK. Anybody-- so that's Matthew. Anybody want to go forward with that, like-- sorry, I can't talk and write something else at the same time. Anybody [AUDIO OUT] that's perfect for things-- while you're speaking, anything with a pitch and a duration. I think an airplane on an airline flight has it's pitch and duration, right? So I'll start calling them notes, too. No, I'm just having fun. Just trying to get us to think so we can start making things, how we're going to make this happen for computer. I like both of these. An instance of striking something, so-- yeah.

AUDIENCE: I feel like that doesn't really apply to certain instruments. Like violins, for example, you don't have to strike anything to issue the next note.

MICHAEL SCOTT ASATO CUTHBERT: Good. So does somebody who hasn't spoken want to defend an instance of striking something as applying to the violin? Yeah, go ahead, Vanessa.

AUDIENCE: I mean, if you want to be annoying, you can use a version of striking in a much more general sense. So if [INAUDIBLE] like hitting anything, could just be when you're moving a bow across strings, you can say that counts as a form of striking, even if it's not the most straightforward definition.

MICHAEL SCOTT ASATO CUTHBERT: OK.

AUDIENCE: Is that a wind instrument?

MICHAEL SCOTT ASATO CUTHBERT: What about a wind--

AUDIENCE: [INAUDIBLE] whistle? [INAUDIBLE].

MICHAEL SCOTT ASATO CUTHBERT: OK.

AUDIENCE: [INAUDIBLE].

AUDIENCE: [LAUGHS]

MICHAEL SCOTT ASATO CUTHBERT: Most of you are juniors and seniors and things. So most of you all have gotten through your physics mechanics general institute requirement. Anybody want to say how sound's produced? Or perceived, maybe? Moving?

AUDIENCE: Vibrations of air.

MICHAEL SCOTT ASATO CUTHBERT: Vibrations of air. Good. And so there's a lot of air vibrating way, way down the street. Why do I not hear it?

AUDIENCE: Inverse square law?

MICHAEL SCOTT ASATO CUTHBERT: The inverse square law. Yes, that might be. But what is not happening with the movement of air?

AUDIENCE: It's not reaching our ears.

MICHAEL SCOTT ASATO CUTHBERT: It's not reaching our ears. It's not-- what is the one of the first thing it reaches in our ears?

AUDIENCE: Eardrum?

MICHAEL SCOTT ASATO CUTHBERT: Eardrum. Oh. So maybe there is a way. So we could say an instance of something striking something, such as air striking a drum. Before half an hour of you go, how many of you would have said that that's a note? OK. What's it striking?

AUDIENCE: There is a strike. You said it's a representation of it.

MICHAEL SCOTT ASATO CUTHBERT: Oh, it's a representation of something striking. Good. Good. OK. Any other things that we want to do with confusing, confusing definitions before we get to one of the points of this class? Any other really great, beautiful things that wasn't covered here? By the way, I forgot to do this part on there.

[PLAYS KEY]

How many notes?

AUDIENCE: Should be three.

AUDIENCE: Three?

MICHAEL SCOTT ASATO CUTHBERT: OK, so if there's something [AUDIO OUT] when you play that, the three different sounds being done could be considered three different notes. So is a chord a note or is a chord a bunch of notes, or is a chord something else? I'd say this because we're going to spend the-- a lot of the first problem set in the next week is going to be on how to represent music for the computers-- for the computers as of the 1960s. [LAUGHS] For a computer.

So what kinds of choices will lead us into bad places fastest? And which ones will keep us in good and useful places for the longest amount of time? Notice I didn't say which ones will never lead you astray, because you're always every definition that you're going to encode into a computer at some point is going to completely screw up something, for instance. We might say one note. Add a little ornament to it. It's still one note in some certain senses, but--

[SCAT SINGING]

--that kind of turn can really change everything. So those are going to be coming up over and over and over again how to represent for a computer and whether or not any one representation is going to work. Somebody said a note is a representation of anything with a pitch and a duration. There are some people who use the term "note" and the term "pitch" absolutely interchangeably. And I do it sometimes also. What pitch was that? What note? What note did you play?

And other people use a note to mean the pitch and the duration as two different entities. Now, obviously, that also leads to certain contradictions. I would hope that we think that an eighth note is a note. Right? I mean, it has the word note in its name. We're not talking about quavers in Britain. I mean, at least here in good old US of A, we put the word note in our eighth notes. But by this definition, pitch and duration and eighth note itself is not a note. Because it doesn't have a pitch.

So we're going to be finding that we're going to be going back and forth quite often. Now, your problem set is going to be dealing with certain representations of pitch, at least the non-duration part of something. I will say I sometimes will pop a head when the lecture is getting too cerebral and things like that. In music21, the software we're going to be using quite often. This is probably the best-- closest definition to how music21 associates things. It's something with a conceived of single pitch and a conceived of single duration.

And that might mean that something like this is conceived of as having a single pitch, or-- this is conceived of as having a single pitch that's a trill sine. But there are other times when we don't conceive of something as a single pitch and duration. So let's talk about representations of duration. So we've gone from the trick questions. And now I hope I haven't ended your faith in humanity in the class. Now I want to go to a little bit more thinking about standard situations, not weird tremolos and glissandos and all that stuff. I want to think about, How are some ways you might represent pitch duration for a computer?

And we'll say-- I'm going to put the term here "musical," as if somehow there's a different world of time in music than there is in everywhere else. There's three kinds of time in the world. There's the one on your clock. There's the one on music. And there's the one they teach you about in relativity class that you hope you never hear again. Right? So thinking about this, what are some ways that you might do it? I think we've grouped enough. I think people want to be able to shout. And some people whose names are toward the beginning and end of the alphabet might want to be able to say so.

What are some of the things that a musical duration representation might include? OK, I think that's a good enough. I think it's like doing jumping jacks. You just get the thinking calisthenics going. So what some of the things that you might do for representing duration? Jordan said something. Yeah.

AUDIENCE: Like seconds or divisions of measures.

MICHAEL SCOTT ASATO CUTHBERT: Seconds. Good. Now let's think about it. We'll make our default assumption for this class that we're thinking in Python, of course. Obviously, any halfway decent programming language can go for another. So how are we going to represent seconds for a note? Yeah, go ahead. Oh, what was that?

AUDIENCE: I guess, typically, don't we use ticks and that sort of...

MICHAEL SCOTT ASATO CUTHBERT: Well, we'll get to that. Keep that word there for a second. Great. But what kind of-- is string a good one? Array? How are we going to represent seconds? Yeah, go ahead.

AUDIENCE: Like a float.

MICHAEL SCOTT ASATO CUTHBERT: Float. OK, good. Why not int? Yeah. Just shout out. Yep, go ahead.

AUDIENCE: Because we can have them between, like--

MICHAEL SCOTT ASATO CUTHBERT: Good. Good. We can have in between. Great. Super. Other things. I'm going to-- other ways you might want to represent duration. Yeah, go ahead Matthew.

AUDIENCE: Fraction?

MICHAEL SCOTT ASATO CUTHBERT: Fraction. Good. Seconds as a fraction or--

AUDIENCE: So I'm thinking both represent seconds as a fraction instead of a float, so you don't have the precision issues of a float. I also think it might make sense to represent it as a beat and fraction.

MICHAEL SCOTT ASATO CUTHBERT: OK, OK. Well, OK, that's the two things. We have beat there. Good, good. We'll keep going. What are some other things that we might do-- yeah.

AUDIENCE: I was also thinking fraction, but fraction of whatever measure you're looking at.

MICHAEL SCOTT ASATO CUTHBERT: Fraction of measure.

AUDIENCE: So if you have like a 3/4 measure, and you had a half note, that would be 2/3 of the measure.

MICHAEL SCOTT ASATO CUTHBERT: Yep. OK. So, good. 2/3. That's a particular place where the difference between float accuracy and fraction can be very, very important. Good. Are beat and fraction of measure basically saying the same thing with reciprocal relationship? Can somebody come up with a reason not to? Yeah.

AUDIENCE: I mean, not necessarily because something could be on the second beat and have a duration of one. Or it could be a second beat and have a duration of two. And if it was a fraction of a measure, their values would be decreasing.

MICHAEL SCOTT ASATO CUTHBERT: OK, good. So we have beat as in what beat is it on? And that would be very different. If we're thinking about, How many beats does it last? OK, so thank you Vanessa. That's fantastic. Is that basically the same as what fraction of the measure is it? I think I see Matthew, but I want to get-- I think I'm going this way because I'm camera shy. So let me lean in over here, see if there's things-- anyone want to-- who says it's basically the same thing? And we can go over. Who says it could be quite different? OK, go ahead.

AUDIENCE: I guess it was like-- it depends on what you define the beat as. So if it's like 5, 8 time or something.

MICHAEL SCOTT ASATO CUTHBERT: Oh, OK. So 5, 8. We'll say we'll do it as this. I don't know if people know that symbol. So how many beats does this get?

AUDIENCE: Two.

MICHAEL SCOTT ASATO CUTHBERT: Two? In some ways. And how many this one? Three. Good. And now give me another number. So we could use instead of that for a lot of 5/8. Yeah.

AUDIENCE: 10, 16.

MICHAEL SCOTT ASATO CUTHBERT: 10, 16. Yeah. We could do any other. Good, good. We have an infinite number of non-reduced fractions we can do. Great. I love it that. How about this? No, I won't write that yet. How many beats does this get?

AUDIENCE: 1, 2, 5.

MICHAEL SCOTT ASATO CUTHBERT: 3 is a good answer. And there's another good answer.

AUDIENCE: 1.

MICHAEL SCOTT ASATO CUTHBERT: 1.

[SCAT SINGING]

1.

[SCAT SINGING]

1, 2. Right? So how many beats does this get?

AUDIENCE: Two beats.

MICHAEL SCOTT ASATO CUTHBERT: So there are some ways of doing it. When I put this symbol, I'm saying I'm going to go 1, 2, 1, 2, 1, 2. And they're not-- so a beat can actually change its length during a measure in some representation. So this is one of the ways I was thinking not exactly the same thing but pretty close. Good, let's see what are some other ways we might represent duration for computer? I'm going to go back in just a little bit the names, some of the things I've heard otherwise. I heard something over here that I think Adam or one of you, Derek.

AUDIENCE: Like an attribute. Like a dot is like an attribute.

MICHAEL SCOTT ASATO CUTHBERT: Great. So we might keep track of attributes like, How many dots does it have? Good. Anything else like that? Thank you. Super. Yeah.

AUDIENCE: Yeah, you take a number for the n-th node. So if it's an eighth note, you say 8. In dots, it'll be an 8 dot.

MICHAEL SCOTT ASATO CUTHBERT: OK. So we can represent it as now-- 8 dot works pretty well as a float, but is there another way we might consider that if we're talking--

AUDIENCE: It works well as a string.

MICHAEL SCOTT ASATO CUTHBERT: It works better as a string, right? Because 8 dot dot, suddenly you're kind of getting a crash error, right? So that's one way you could do it. Other ways? And then so we would say or something like that. Good, good. What are other attributes we might want to represent to talk about the duration of a note? Are all notes-- yeah.

AUDIENCE: You could also have these at a triplet.

MICHAEL SCOTT ASATO CUTHBERT: You could have things in a triplet. Yeah. Good. You could also have things in a quintuplet, right? Let's see if I can squeeze this in. And you can also have things in a triplet within a quintuplet. It's called nested tuplets. So I will guarantee you, I have seen at least 20 representations of notated durations where the tuplet was originally created as an attribute, and then it needed to be represented as a list array tuple, something like that of a tuple of tuplets-- try to say that 10 times fast-- for indeterminate number of tuplets that might be applied to a certain note. So these might be certain things. Good. Anything else that we might use to represent duration? Yeah, go ahead.

AUDIENCE: Certain markings like staccato or legato?

MICHAEL SCOTT ASATO CUTHBERT: Good. So we might have modifying, I don't know, articulations and expressions or markings. We'll just call them markings because who knows what they are? Markings. I'll make a fermata on my I. Good. So yeah, we have our dots maybe modifying. Good. So we can think of tornadoes that those affect the duration. Great. Now I want to go towards further on this. Now our music is on a-- I was going to use obsolete formats, a CD or streaming. What are the most useful representations of duration? Of notes, let's say. Or other things, which once these are most useful?

And I've heard you a couple of times from you. So great. Super. M's got it. Who else got one? Is this a great representation that you're hearing of the duration of a note when you're listening to streaming music? Maybe not, but boy, that could be useful for other things. What about seconds? That's going to depend on-- let's say you're listening just for fun. Seconds very good? No, maybe not. I don't usually hear seconds, but who's somebody who involved in the streaming music process who might really care about seconds of notes?

AUDIENCE: I guess the computers in a sense.

MICHAEL SCOTT ASATO CUTHBERT: The computers way? Yep, but what kind of human might be really interested? Yeah.

AUDIENCE: Some editor.

MICHAEL SCOTT ASATO CUTHBERT: The editor. Yeah, the person who's doing the recording editing, they're always going to be thinking about, OK, let's clip from 22.046 to 22.048 when somebody coughed. And we'll come up with something, right? So those types of things come up quite a bit in that type of world. Now what if you've written your great piece. It's already been recorded, performed and things. And now you've sent it off to your sheet music publisher. What are the ones they're going to care the most about? What's the representation? Yeah, John.

AUDIENCE: Pitch and duration.

MICHAEL SCOTT ASATO CUTHBERT: The pitch and the duration. Good. And how are they going to be thinking about duration? How is the engraver? That's the person who makes musical scores, the term for that. What's the engraver? What's she going to be thinking about in terms of duration? What do you think about when you're looking at musical scores? Yeah.

AUDIENCE: The beat and then the modifying components?

MICHAEL SCOTT ASATO CUTHBERT: The beats, the modifiers. Good. Good. What are we going to call something, the difference between an eighth note, a quarter note, half note, all that stuff? What do we want to call that? We all have been doing music for a very long time. We all must know the term for that, right? There is no generalized term for it. So what do we want to call it in this class? Somebody shout out something, or we'll call it the note animal. What animal is this note, or what flavor is this note? That's a good one. Actually, I wish I had gone with that. Mhm, mhm, yum, 16th notes are really, really tasty today. Anybody have a suggestion of a term?

AUDIENCE: Essence?

MICHAEL SCOTT ASATO CUTHBERT: The essence. What essence of note is. Good. Good. I will tell you that essence is better than animal probably as a term. It's probably better than flavor. And it's better than what all the rest of us didn't say. Because the first thing you have to do when you're representing for a computer is come up with a name for everything. Yeah, Vanessa.

AUDIENCE: [INAUDIBLE].

MICHAEL SCOTT ASATO CUTHBERT: OK. But come up with a name for it.

AUDIENCE: Duration.

MICHAEL SCOTT ASATO CUTHBERT: The duration. OK, so we might have the duration of a duration is a quarter. And the number of dots is 2. A lot of representations do that. I think MEI calls that part a duration. So that's a very good term for it. Other terms. Get good at naming things. Come up with names fast in this class. So let's just pepper some bad names for it. Jonathan, what's it?

AUDIENCE: Almond.

MICHAEL SCOTT ASATO CUTHBERT: The almond. What almond is it? Jonathan.

AUDIENCE: I mean, I guess the length [INAUDIBLE].

MICHAEL SCOTT ASATO CUTHBERT: What length. Good. What length is that note? It's a quarter note. What length is that note? It's an eighth note. There might be a better term, but that's a pretty good one. That's good. Yeah.

AUDIENCE: I feel like spanned is--

MICHAEL SCOTT ASATO CUTHBERT: What span? I like that. What span? It might not be so perfect, but it gets us-- when you think about things, what's something that spans things that people spend a lot of time, especially at what course 3 thinking about?

AUDIENCE: Bridges.

MICHAEL SCOTT ASATO CUTHBERT: Bridges. Good. And when you start thinking about bridges, what's something that we haven't even thought of that looks like a bridge when we think about durations and notes?

AUDIENCE: Slurs.

MICHAEL SCOTT ASATO CUTHBERT: Slurs, ties. Good. Slurs, ties. I was also thinking of beams. Any of those? Good. So we start when we start thinking of terms like this, we start thinking of cases who had thought about ties and slurs in your definition? Who had thought about beams? I hadn't thought of ties. And so when we do these types of things, suddenly why something is a good name or might not be a good name can help us think about what other things we're going to have to represent. I'm looking at the time. We're not going to be able to get through all the different types of representations here, but good.

Now, what would it take-- let's say you have this. What's it going to take that dotted quarter note? That's not a trick question. What's it going to take for you to figure out how many seconds that is? Who has performed music from sheet music in class in real life? OK. Basically, everybody. So when you do that, you have to decide how long you're going to play that, right? You might not even be thinking it in your head, I've never been like, OK, I'm going to play that for 0.365 seconds. How do we go from this to a number of seconds? Yeah, go ahead. Oh, I'm sorry. There was two in a row. We're going behind first.

AUDIENCE: Well, it's based off the template.

MICHAEL SCOTT ASATO CUTHBERT: Based off the tempo. Good. Has tempo been included? I suppose it's almost implicitly included in beat, but tempo is a particular term. So we have tempo. How do we measure tempos? Tempi. Tempi.

AUDIENCE: Beats per minute?

MICHAEL SCOTT ASATO CUTHBERT: What's that?

AUDIENCE: Beat per minute.

MICHAEL SCOTT ASATO CUTHBERT: Beat per minute. Good. Beat per minute. So what do we need to know? Also, in addition to tempo, in order to figure out how many beats something is. We all think of 4/4, right? Yeah, Jake.

AUDIENCE: You intentionally say 0.365. This is 3/8 of [INAUDIBLE] 375.

MICHAEL SCOTT ASATO CUTHBERT: 375. But yeah, but whatever. I don't know. It was something like that. Yeah. I very rarely do anything intentionally. So maybe it's karma.

[LAUGHTER]

What do we need to do to get beats per minute? How many beats is this?

AUDIENCE: It depends.

MICHAEL SCOTT ASATO CUTHBERT: Depends. Good. Depends on the-- everybody, shout it out. Time signature. Good. So suddenly, moving from this representation of notes to seconds, we need tempo in beats per minute and a time signature. Good. Let me give you another one. What if I said the tempo here was allegro troppo? OK, the other thing. If it gets too much longer than that, the other thing we need is an Italian dictionary, right?

[LAUGHTER]

Allegro, but not too allegro. Not too much. So what do we need also in order to convert this to seconds? Let's take a stab at it. You guys have all been speaking pretty well. Hannah, I don't think I've heard from you in a little bit. What would you say you need in order to convert this to--

AUDIENCE: I guess a knowledge of what it means?

MICHAEL SCOTT ASATO CUTHBERT: A knowledge of?

AUDIENCE: What it means in terms of the conversion.

MICHAEL SCOTT ASATO CUTHBERT: Knowledge of-- good. Knowledge of a conversion. Can you give me a conversion, maybe what it means? Conversion to, let's say, BPM. What would be-- Hannah, if you want to or pass it along to somebody else. Take a stab, what are you going to name that? Allegro approximately? 7?

AUDIENCE: Yeah.

MICHAEL SCOTT ASATO CUTHBERT: OK. 2 million. OK, good. We're narrowing it down.

AUDIENCE: But you're on 110.

MICHAEL SCOTT ASATO CUTHBERT: 110. Good. Anybody want to go higher than 110? What do you want to go with?

AUDIENCE: 126.

MICHAEL SCOTT ASATO CUTHBERT: 126. Very specific number. Anyone want to go lower? I'm going to go a little bit lower and say 90. Because the other thing that you need to know is the cultural context. And because each of these things changes so much, Handel has a tempo marking of allegro adagio.

AUDIENCE: Oh.

MICHAEL SCOTT ASATO CUTHBERT: What does that mean? Those are like contradictions. That's like, How do you like your cereal? I like it hot cold. Yeah, but at a particular time, that is-- so sometimes we ignore quite a lot of these, right? I know I use-- and by the way, had a pretty close-- I think I use 118 in a lookup table when I have no idea what I want to do from allegro. Or sometimes I've used 126. I've used other things, 110s. 110 I usually use is the-- it depends on whether or not I have a conception of the term allegretto, in which case I need to make room for that. But yeah, 110 is also very good.

Good. By the way, every guest that people are doing has been really, really, really good in this class. So just keep taking the guess, and when we start talking too much, then I'll slow it down. But it's good. So these are all the various things that we might do to convert from one to another. There was one other way that we could measure duration that I think Marlon said that I was like, not yet, not yet, not yet, but becomes very important. Do you remember what we said? Ticks. Good. So you can measure on the number of bugs that get into your hair when you go hiking, right? No, what do we mean by ticks? This has a different meaning than--

AUDIENCE:

From my understanding. It's how the process, like whatever program or application you're running and that measures and ticks. And so that kind of dictates what a second is based on it.

MICHAEL SCOTT ASATO CUTHBERT: Great. Yeah, so what we can do is we can think of time as somehow discrete. That time moves forward. And by the way, there's some theoretical physicists who have been trying to study whether time actually is discrete and moves forward in, I don't know, 10 to the negative 58th seconds or not. But that we can think of musical time as a discrete number of something in a purely computer world, like ticks, which is both brilliant and a way of just shuffling later to some other later part of the program, the actual conversion of this to seconds, or to quarter notes or to eighth notes or anything like that.

But it's very, very useful. The one term that you may have heard of before MIDI, the MIDI file format, the MIDI things MIDI tends to measure everything in ticks. There's some things that are not-- and it's a little bit of a simplification. So ticks end up being ticks per second or ticks per-- ticks per second is a pretty good one for tempo. And the other one ticks per quarter note, comes up quite a lot. Intriguingly, because of the problem of 6, 8 and 5, 8, and these weird things, fundamental measurements in terms of beats have not primarily been taken on by people who do musical representation.

It's generally seen as a slightly higher representation, which is ironic because it's one of our fundamental ones for as musicians, right? I mean, you think of that, oh, that last half note, it lasts two beats, right? And then somebody reminds you, oh, what about cut timing? Like, you ruin everything, right? Because we generally do some things like this. I will share now what I ended up in my program in music21 decided that for some reason, the quarter note is the fundamental measure of everything else so that everything sends are measured in quarter lengths, which is a terrible term. Boy, I wish I had come up with something better.

Essence, that's-- almonds. I wish I had measured in almonds, because quarter length takes a very long time to type with a camel case in the middle. And we didn't have-- what is it? GitHub, Autopilot, and things like that. Yeah, and by the way, I didn't mean to put no ChatGPT on the syllabus. I put it on the thing later today. You have fun with it, but not when we're doing any writing your essay or anything like that. But maybe we'll come up with a chat music or something later on this semester and try to see how we can do things like that. But yeah, I wish I had come up with a better thing, but almost everything measured in quarter lengths. What's nice about that is how many quarter lengths is a quarter note?

AUDIENCE: One.

MICHAEL SCOTT ASATO CUTHBERT: One. Good, good, good. We're all still awake. I know it's Friday late and things, but yeah. So how many quarter lengths is a quarter note in 6, 8?

AUDIENCE: One.

MICHAEL SCOTT ASATO CUTHBERT: One. How many quarter lengths is a quarter note in allegro? One. So these things and-- but then how many seconds is something that's 1.5 quarter lengths? Ah, now you have to keep up with everything. So you can think about when you're thinking about-- now let's get to the first word in this class. It's not representational music theory. It's computational. When you're starting to think about-- I'll abbreviate it quite often as ql to sec.

And maybe we'll say secs or floats in this case. I've used a lot of typed Python, by the way, where if you haven't ever seen this, you'll put this in to say what I expect to do. So it's sort of all the joys of having to type more things without type safety. It's not so good. But what do we want to put in as our attribute or attributes here? We're going to return a float. What's the first thing that we need? ql to seconds?

AUDIENCE: How many ql's?

MICHAEL SCOTT ASATO CUTHBERT: How many ql's. Yeah, so maybe it'll be ql. Some people like to do ql in, and that's going to be measured in-- what do we want to make that?

AUDIENCE: Floats.

MICHAEL SCOTT ASATO CUTHBERT: Float. Good. It could be a float. It's probably not good enough. Name something not representational as an int in quarter lengths.

AUDIENCE: Eighth.

MICHAEL SCOTT ASATO CUTHBERT: Eighth note. Good, good. The issue-- I tend to sometimes use the fraction class, if you haven't ever done that because of the first time they had three triplets add up. Actually, triplets work fine. Five quintuplets adds up to 1.0000124 [MUMBLES] quarter notes. That's why I started moving that. But float's pretty good. Good. So that's attribute 1. Anybody want another attribute in there? Quarter length second. Yes.

AUDIENCE: The tempo?

MICHAEL SCOTT ASATO CUTHBERT: Tempo. Good. So we can define a tempo object. And now we're going to see-- or struct or some kind of thing. Well, tempo could be a basic thing. It could be a float, right? What else could it be? What do we-- if we're not thinking about allegro non troppo as used by Handel as opposed to Mendelssohn or something like that, what do we-- Yeah.

AUDIENCE: Beats per minute.

MICHAEL SCOTT ASATO CUTHBERT: Beats per minute. OK. So we have beats per minute. That's the most common one, right? So that's going to be-- how would you measure beats per minute? Oh sorry, how do we want to represent it?

AUDIENCE: Float.

MICHAEL SCOTT ASATO CUTHBERT: Float. Good. So we pass it in first thing a quarter length. Second thing, a tempo. Is that enough? Why not?

AUDIENCE: Time signature?

MICHAEL SCOTT ASATO CUTHBERT: Time signature. In order to define-- what are we defining by the time signature?

AUDIENCE: How many beats a quarter length is?

MICHAEL SCOTT ASATO CUTHBERT: Great. Beats per quarter length. So ts will measure in beats per quarter length. And what do we want to make that also?

AUDIENCE: Float.

MICHAEL SCOTT ASATO CUTHBERT: Float. Good. Let's do this. You don't need any-- go ahead, grab laptops. Let's implement quarter length to second. Let's do it as paired programming, so we learn from each other. So the person on the left is the-- who's done paired programming? Person on the left is the driver, unless the person on the left doesn't have the thing. And that's your left, not my left. And everybody else will-- 4:34, we'll take about 10 minutes.

[SIDE CONVERSATION]

MICHAEL SCOTT ASATO CUTHBERT: OK. Just before we continue and start going on with things, how many people wrote five test cases before you started?

[LAUGHTER]

How many people wrote 10 test cases? How many people wrote one test case? One test case? How many people wrote zero test cases? OK, you're going to hear this a couple times in the next class and stuff. And this is very different-- guys, just one second. I'm going to get back into it. Very different from a lot of the especially intro level CS classes at MIT. But because this isn't a really big established field, I told all of you all that you're really-- this is one of the very few classes like this, right?

One of the really important things is writing test cases and especially looking at corner cases. So get in the habit of this. You're going to-- if I'm feeling nice, I might give one or two test cases with correct answers on things. But a lot of it is sit down and think at 60 beats per minute, at 4, 4 what's the answer for a quarter note for one?

AUDIENCE: One.

MICHAEL SCOTT ASATO CUTHBERT: One. Good. At least, make sure your code does that before you go on. So keep going. Try some running and try some--

[LAUGHTER]

OK, let's all come back together for a bit because this isn't the problem set. And I want to move on and thinks. One of the terms I heard a lot was this one. Let's do a dimensional analysis or things like that. For somebody who didn't use that term or who doesn't-- we're all coming from different backgrounds and things. What's a dimensional analysis?

AUDIENCE: Stoichiometry?

MICHAEL SCOTT ASATO CUTHBERT: Stoichiometry. Well, thank you for obfuscating further. [LAUGHS] We'll get you on the call-- what's that called?

AUDIENCE: Stoichiometry.

MICHAEL SCOTT ASATO CUTHBERT: Stoichiometry. I must have failed trigonometry, so I didn't get to that one.

[LAUGHTER]

OK, what might that mean? Honestly, I just learned a new word. Thank you.

AUDIENCE: Just dimensional analysis for chemistry.

MICHAEL SCOTT ASATO CUTHBERT: That's just dimensional analysis for chemistry. OK, good. Remember, I was up the river, so we didn't learn these things. What do we mean when we're talking about dimensional analysis? Yeah.

AUDIENCE: It's like a conversion between equivalent units?

MICHAEL SCOTT ASATO CUTHBERT: A conversion between equivalent units. Good. What are some dimensional analysis things you've done before this class? Yeah.

AUDIENCE: Physics?

MICHAEL SCOTT ASATO CUTHBERT: Physics. So what's a dimension? What's a kind of--

AUDIENCE: Trying to convert like-- um, like trying to convert like you say meters per second to miles per hour.

MICHAEL SCOTT ASATO CUTHBERT: Great. Meters per second to miles per hour. Absolutely. Thank you. So we have the particular conversion there. So we have meters, seconds, miles, hours. What were some dimensionality things-- dimensions that you use now that you might not have used in your past before? Yeah.

AUDIENCE: Beats quarter lengths.

MICHAEL SCOTT ASATO CUTHBERT: Beats per quarter length. Quarter length per beat. Good. Beats quarter lengths? Absolutely. You've probably heard beats per minute. Not everybody has thought of it as, OK, then I have to convert to beats per second, which is not something we think about. We're very, very good at thinking about beats per minute. As musicians, we're very, very bad at think about beats per second or seconds per beat. And then beats per-- what was the other thing? Beats per quarter length. Awesome.

So that came up quite a bit on things going on. What were some other things that seemed to stump or be fun or interesting, or that you learned from programming this? I heard a lot of, we don't need the time signature. I think I heard that allowed at least three or four times. But what do you do if you have the time signature? And the problem-- and let's say we're leaving out that 5, 8 where the beat changes stuff? How do we convert from time signature-- think of time signature first as a two tuple of numerator and denominator. How do you convert a numerator and denominator into beats per quarter length? What is 4 4. How many beats per quarter length?

AUDIENCE: 1.

AUDIENCE: 1 1.

MICHAEL SCOTT ASATO CUTHBERT: Good. What is 2/2?

AUDIENCE: 1.

[INTERPOSING VOICES]

AUDIENCE: One.

MICHAEL SCOTT ASATO CUTHBERT: How many beats-- oh, good. I did hear it, but I heard a lot of-- I love it. This is what I'm hoping to get to his class. I heard a lot of very loud wrong answers, and then very, very trickling right at the end, a little whispered right answer. How many beats per quarter length for cut time for 2 2.

[INTERPOSING VOICES]

AUDIENCE: 2.

MICHAEL SCOTT ASATO CUTHBERT: 2 2. And I also heard whispered. Somebody had--

AUDIENCE: 1/2.

MICHAEL SCOTT ASATO CUTHBERT: 1/2. How many beats does it take to play a quarter note in 2 2? How long does each of these-- is that correct? Am I wrong this time?

AUDIENCE: Half a beat.

MICHAEL SCOTT ASATO CUTHBERT: Half a beat. This is half a beat, and it gets a quarter note. This is half a beat, and it gets a quarter note. OK, what about in 3 2?

AUDIENCE: It's 1/2.

MICHAEL SCOTT ASATO CUTHBERT: 1/2. So what part do we not need?

AUDIENCE: The numerator.

MICHAEL SCOTT ASATO CUTHBERT: Numerator. So for this particular thing, we don't need the numerator. We would if we're-- yeah, go ahead, Matthew.

AUDIENCE: Do we need the numerator in 6 8?

MICHAEL SCOTT ASATO CUTHBERT: Do we need the numerator in 6 8? Yes. So what do we need the numerator for? We only need the numerator to do a modulo operation to compare if it equals 0. But is that good enough? Because 6 8, 9 8, 12 8, these all generally default in most conceptions, not all, but in most conceptions as the number of beats is divided by 3 on that. So is that good enough? Does everyone know modulo notation like the remainder when divided by 3 equals 0? So does that work? 6 8? Great. 8 8? Nope. That's a normal one. 9 8, great. So 6 4, great. How many beats does 6 4 have? Treated in this way?

AUDIENCE: Two.

MICHAEL SCOTT ASATO CUTHBERT: Two. Two. 1, 2. 1--

[SCAT SINGING]

2. Yeah, I say it has two. And I mean 1, 2, 3, 4. But I'm giving you the big one. Great, so 6 4. How many does 9 16 have?

AUDIENCE: 2 3?

MICHAEL SCOTT ASATO CUTHBERT: Great. So this works, right? We have all our good test cases there? Yeah, you're smiling big. Anyone else smiling big? You're smiling big. What's the test case we've missed?

AUDIENCE: 3 4?

MICHAEL SCOTT ASATO CUTHBERT: 3 4. So 3 4 has one beat, because you divide by 3. So what do we have to do? If the numerator modulo 3 equals 0 and num not equals 3, right? That's assuming we've already done our assertion that numerator is positive and all the other things, right? So these are the algorithms that you already know in your head for music by being musicians. But they are not the algorithms that you have been programming before.

Here's a particular one that I always like to do, and I think we're going to have time to go through it today, because you guys have been such great participants in my terrible ploys and things. Given a note, given a quarter note, let's say. We'll keep it really simple because we're already in. We'll call it quarter note one quarter length, one beat or something. Given a dot, how many beats?

AUDIENCE: 155.

MICHAEL SCOTT ASATO CUTHBERT: 155? Given two dots.

AUDIENCE: 1.73.

MICHAEL SCOTT ASATO CUTHBERT: Three dots.

AUDIENCE: 1.83.

MICHAEL SCOTT ASATO CUTHBERT: Oh, somebody had it. That will be a trail off. Good. n dots. What is the formula?

AUDIENCE: 2 minus--

AUDIENCE: 2 to the negative 1.

MICHAEL SCOTT ASATO CUTHBERT: Oh, something-- yeah. So working this out-- and if you want, I'll put a link online. Once, I originally had to write out this formula because I kind of needed it. It becomes fun. Yeah, so it ends up being-- what do you call it? These are Mersenne numbers which are not the same as Mersenne primes. They end up being n minus 1. What is it? 2 to the n minus 1 over 2 to the n. So you end up 1 and 1/2, slightly under. 1 and 3/4, 1 and 7/8. So 2 to the n, whatever.

So you can figure out, OK-- and hopefully that works. 2 to the 0. Sorry, that goes down below. That's not part of the exponent. I should make that nicer. 2 to the n minus 1 over 2 to the n. Sorry, I haven't been writing on whiteboards in a year, so my technique's a little low. So does that work? Or 1 plus, right? Yeah. So does that work for zero dots? What's 2 to the zeroth? What's 2 to the zeroth?

AUDIENCE: 1.

MICHAEL SCOTT ASATO CUTHBERT: 1. Minus 1 is 0. So that cancels that out as long as that's not 0 there. Good. So you get 1. What happens if you have a negative 1 dot? 2 to the negative 1?

AUDIENCE: It is 1/2.

MICHAEL SCOTT ASATO CUTHBERT: 1/2. Minus 1?

AUDIENCE: Negative 1/2.

MICHAEL SCOTT ASATO CUTHBERT: Negative 1/2 over 2 to the negative 1?

AUDIENCE: Uh, over 1/2.

MICHAEL SCOTT ASATO CUTHBERT: Over 1/2. What's that end up? Negative 1/2 over 1/2? 1 plus--

AUDIENCE: 2.

AUDIENCE: Negative 1.

MICHAEL SCOTT ASATO CUTHBERT: Negative 1 equals?

AUDIENCE: 0.

MICHAEL SCOTT ASATO CUTHBERT: 0. So every time you don't hear any music, know you're hearing the grand symphony of negative 1 dots. I think that's a good place to wrap up.