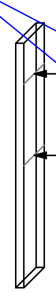
9.2 Musical tones

9.2.1 Wood blocks

Here is a home musical experiment that illustrates proportional reasoning and springs. First construct, or ask a carpenter or a local lumber yard to construct, two wood blocks made from the same larger wood plank. Mine have these dimensions:

1. 30 cm × 5 cm × 1 cm; and
2. 30 cm × 5 cm × 2 cm.

The blocks are identical except in their thickness: 2 cm vs 1 cm.



Now tap the thin block at the center while holding it lightly toward the edge, and listen to the musical note. If you do the same experiment to the thick block, will the pitch (fundamental frequency) be higher than, the same as, or lower than the pitch when you tapped the thin block?

You can answer this question in many ways. The first is to do the experiment. It would be nice either to predict the result before doing the experiment or to explain and understand the result after doing the experiment.

One argument is that the block is a resonant object, and the wavelength of the sound depends on the thickness of the block. In that picture, the thick block should have the longer wavelength and therefore the lower frequency. A counterargument, based on a different model of how the sound is made, is that the thick block is stiffer, so it vibrates faster. On the other hand, the thick block is more massive, so it vibrates more slowly. Perhaps these two effects – greater stiffness but greater mass – cancel each other, leaving the frequency unchanged?

I'll do the experiment right now and tell you the result. The thick block has a higher pitch. So the resonant-cavity model is probably wrong. Instead, the stiffness probably more than overcomes the mass.

A spring model explains this result and even predicts the frequency ratio. In the spring model, a wood block is made of wood atoms connected by

I feel like you covered a variety of examples and this is the first time involving music. I am quite happy.

For Wednesday (memo due at 9am on Wed), read about the wood-block demonstration from lecture. Then we'll talk more about physics and music (provided I'm not in the delivery room at Mt Auburn hospital).

I like this introduction. It seems abstract, but you know it is building up to a meaningful conclusion

This was a cool example to see in class! I really like how the readings tie to the lectures, but I also think even for people who don't take 6.055 (which will probably be the case for most readers of this text), that the examples are so interesting to read about and the explanations are very clear.

I know, I'm ashamed I couldn't remember the results of this from streetfighting math..

I like the idea of using springs as music, but the more classical idea of springs. I wonder how that would work...not just vibrational motion but like a slinky

I see that this could be a good way to make the point, but do you really expect anyone to have a carpenter or lumber yard worker make this for them?

I realy don't think that's relevant...

Haha yeah pretty irrelevant

Also, it's not really construction. Most places will happily cut down lumber for you.

Rather than instructing the reader in how to acquire the wood blocks you could simply ask them to acquire blocks - if you're target audience is MIT students I would assume they are capable of figuring out a way to get two wood blocks.

I also assume that this statement applies to the average person as well!

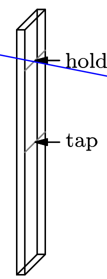
9.2 Musical tones

9.2.1 Wood blocks

Here is a home musical experiment that illustrates proportional reasoning and springs. First construct, or ask a carpenter or a local lumber yard to construct, two wood blocks made from the same larger wood plank. Mine have these dimensions:

1. 30 cm × 5 cm × 1 cm; and
2. 30 cm × 5 cm × 2 cm.

The blocks are identical except in their thickness: 2 cm vs 1 cm.



Now tap the thin block at the center while holding it lightly toward the edge, and listen to the musical note. If you do the same experiment to the thick block, will the pitch (fundamental frequency) be higher than, the same as, or lower than the pitch when you tapped the thin block?

You can answer this question in many ways. The first is to do the experiment. It would be nice either to predict the result before doing the experiment or to explain and understand the result after doing the experiment.

One argument is that the block is a resonant object, and the wavelength of the sound depends on the thickness of the block. In that picture, the thick block should have the longer wavelength and therefore the lower frequency. A counterargument, based on a different model of how the sound is made, is that the thick block is stiffer, so it vibrates faster. On the other hand, the thick block is more massive, so it vibrates more slowly. Perhaps these two effects – greater stiffness but greater mass – cancel each other, leaving the frequency unchanged?

I'll do the experiment right now and tell you the result. The thick block has a higher pitch. So the resonant-cavity model is probably wrong. Instead, the stiffness probably more than overcomes the mass.

A spring model explains this result and even predicts the frequency ratio. In the spring model, a wood block is made of wood atoms connected by

I think it would be helpful to say that they are long thin planks rather than blocks, which i would say is a more accurate description of the geometry

I agree...one of the key points from the experiment done in class was that the blocks were identical except for a slight difference in the thickness.

This is interesting, but I have no idea where this is going. This may be a good thing though if explained well, since musical examples are usually lost on me

if they're the same wood plank, wouldn't they have the same thickness? this is a misleading statement.

If this were instead dealing with metal, would the oppose hold true? would the larger piece have a lower frequency?

Maybe instead of including the exact dimensions here, add them into the diagram?

i think you can skip the stuff before this, with the details of asking someone to construct a block for you, and their dimensions. this sentence is sufficient and brings the focus the difference between the two blocks, the real item in question here

I agree. I find the "ask a friend" thing to be a little silly. To me, that's like saying on a homework problem, "first go to the store and buy some paper and a pencil to write down your answers with..."

This is being presented as a home experiment. What kind of Mickey Mouse experimenter would skip details about dimensions and construction? This sentence is just a brief expansion explanation of the above numbers.

I agree with all of this; you might just want to start with: "I have two wood blocks of dimensions...".

I like starting with examples though, it gives me something to picture as I'm going through the reading and it makes it more interesting.

I agree one of the things i like about this book is it's not all fact fact fact. There's actual transition and side stories/information that make it much more interesting to read.

Well, I actually thought it was kind of amusing, but I can see how it is detracting.

It's only 3 sentences...I feel like a 3 sentence intro is completely fine.

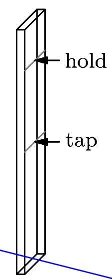
9.2 Musical tones

9.2.1 Wood blocks

Here is a home musical experiment that illustrates proportional reasoning and springs. First construct, or ask a carpenter or a local lumber yard to construct, two wood blocks made from the same larger wood plank. Mine have these dimensions:

1. 30 cm × 5 cm × 1 cm; and
2. 30 cm × 5 cm × 2 cm.

The blocks are identical except in their thickness: 2 cm vs 1 cm.



Now tap the thin block at the center while holding it lightly toward the edge, and listen to the musical note. If you do the same experiment to the thick block, will the pitch (fundamental frequency) be higher than, the same as, or lower than the pitch when you tapped the thin block?

You can answer this question in many ways. The first is to do the experiment. It would be nice either to predict the result before doing the experiment or to explain and understand the result after doing the experiment.

One argument is that the block is a resonant object, and the wavelength of the sound depends on the thickness of the block. In that picture, the thick block should have the longer wavelength and therefore the lower frequency. A counterargument, based on a different model of how the sound is made, is that the thick block is stiffer, so it vibrates faster. On the other hand, the thick block is more massive, so it vibrates more slowly. Perhaps these two effects – greater stiffness but greater mass – cancel each other, leaving the frequency unchanged?

I'll do the experiment right now and tell you the result. The thick block has a higher pitch. So the resonant-cavity model is probably wrong. Instead, the stiffness probably more than overcomes the mass.

A spring model explains this result and even predicts the frequency ratio. In the spring model, a wood block is made of wood atoms connected by

How much of a difference does the strength at which you hold it end up mattering? Shouldn't it be the same, as long as you do it the same for both blocks?

I would think yes. I think what he's trying to say is that you need to hold the blocks lightly enough to allow the blocks to vibrate as freely as possible. If you hold them with enough pressure, you could dampen the vibration enough as to make the experiment worthless.

Yeah I'm pretty sure that's what he's saying as well - you don't want to add damping to the vibrations.

I hold them at the "node" – the spot that doesn't move, so it is less sensitive to my pressure.

Maybe you could minimize the human error from holding it by attaching the block to a string and holding the string in your hand, maybe you would have to drill a hole in the wood to thred the string through.

As a phrasing issue, I would suggest that "lightly" be replaced by "loosely."

Maybe draw a hand here to show where you hold it - "toward the edge" seems ambiguous to me.

I agree, especially since holding the block at the "node" will decrease the sensitivity to the pressure of holding it.

How far toward the edge though? How can we tell where the "node" is?

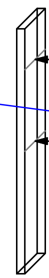
9.2 Musical tones

9.2.1 Wood blocks

Here is a home musical experiment that illustrates proportional reasoning and springs. First construct, or ask a carpenter or a local lumber yard to construct, two wood blocks made from the same larger wood plank. Mine have these dimensions:

1. 30 cm × 5 cm × 1 cm; and
2. 30 cm × 5 cm × 2 cm.

The blocks are identical except in their thickness: 2 cm vs 1 cm.



Now tap the thin block at the center while holding it lightly toward the edge, and listen to the musical note. If you do the same experiment to the thick block, will the pitch (fundamental frequency) be higher than, the same as, or lower than the pitch when you tapped the thin block?

You can answer this question in many ways. The first is to do the experiment. It would be nice either to predict the result before doing the experiment or to explain and understand the result after doing the experiment.

One argument is that the block is a resonant object, and the wavelength of the sound depends on the thickness of the block. In that picture, the thick block should have the longer wavelength and therefore the lower frequency. A counterargument, based on a different model of how the sound is made, is that the thick block is stiffer, so it vibrates faster. On the other hand, the thick block is more massive, so it vibrates more slowly. Perhaps these two effects – greater stiffness but greater mass – cancel each other, leaving the frequency unchanged?

I'll do the experiment right now and tell you the result. The thick block has a higher pitch. So the resonant-cavity model is probably wrong. Instead, the stiffness probably more than overcomes the mass.

A spring model explains this result and even predicts the frequency ratio. In the spring model, a wood block is made of wood atoms connected by

When asked to think about this casually, I would have said lower. When asked to think about it as an engineer, I would have said higher. Is it weird that I still separate those mental states?

I did the same thing. There seem to be competing preconceptions here - like bigger objects tend to make deeper sounds but thinner objects can vibrate more easily. Even though I followed the logic in the reading, if you were to ask me a related problem in the future my instincts would still be divided.

I originally thought lower, but thinking of guitar luthiery, one constructs a thicker top to get more clarity in the tone, which is typically understood to be more of the higher overtones and fewer low overtones, a direct correlation to this question. Also interesting is the use of a "tap tone" in guitar construction to correctly voice a top.

Don't know if my train of thought is right, but my first reaction was that the thicker would create a higher pitch, since it vibrates faster, but then I thought about playing a violin and how the highest pitch string is the thinnest. But then I thought more, and the thinnest one is strung tightest, so vibrates fastest still...

If you don't refer to "fundamental frequency" later in the text, is this parenthetical necessary?

The fundamental frequency is a very specific quality of a subject. It may not be entirely necessary, but it is appropriate and accurate.

Is this because what we hear is the fundamental frequency, and not overtones?

The period of sound with a fundamental frequency is the smallest repeating unit of a signal. Overtones, on the other hand, are resonant frequencies that are higher than the fundamental frequency.

You hear the overtones as a "coloring" of the fundamental. That's why a harpsichord and a piano playing the "same" note (the same fundamental) sound like the note is the same pitch but sounds different (the harpsichord sounds more metallic, because it's overtones are stronger).

Actually, the fundamental frequency is so powerful that you hear the fundamental even if it is not there (that's how telephone receivers, or small portable radios, sound at all okay).

9.2 Musical tones

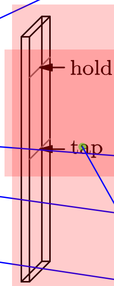
9.2.1 Wood blocks

Here is a home musical experiment that illustrates proportional reasoning and springs. First construct, or ask a carpenter or a local lumber yard to construct, two wood blocks made from the same larger wood plank. Mine have these dimensions:

1. 30 cm × 5 cm × 1 cm; and
2. 30 cm × 5 cm × 2 cm.

The blocks are identical except in their thickness: 2 cm vs 1 cm.

Now tap the thin block at the center while holding it lightly toward the edge, and listen to the musical note. If you do the same experiment to the thick block, will the pitch (fundamental frequency) be higher than, the same as, or lower than the pitch when you tapped the thin block?



You can answer this question in many ways. The first is to do the experiment. It would be nice either to predict the result before doing the experiment or to explain and understand the result after doing the experiment.

One argument is that the block is a resonant object, and the wavelength of the sound depends on the thickness of the block. In that picture, the thick block should have the longer wavelength and therefore the lower frequency. A counterargument, based on a different model of how the sound is made, is that the thick block is stiffer, so it vibrates faster. On the other hand, the thick block is more massive, so it vibrates more slowly. Perhaps these two effects – greater stiffness but greater mass – cancel each other, leaving the frequency unchanged?

I'll do the experiment right now and tell you the result. The thick block has a higher pitch. So the resonant-cavity model is probably wrong. Instead, the stiffness probably more than overcomes the mass.

A spring model explains this result and even predicts the frequency ratio. In the spring model, a wood block is made of wood atoms connected by

I really like this graphic. For some reason, I found the verbal description of this a bit confusing, but the picture really clears up what you mean.

I agree, if you didn't see the demonstration, it may be unclear where the "center" of the board is exactly.

Agreed. And I didn't even see this figure until after I read the entire page. It does reduce some confusion.

The graphic does help a lot, would it be possible to insert some hand shaped image where you ask the user to hold the block?

It's going to be lower, right

I think you missed lecture that day :-P We already did the experiment in class. My reaction was to expect lower too, but the thicker piece was actually higher pitch.

Yeah, I was surprised by that too.

My reaction was that a rigid, stiffer object will vibrate at a higher frequency (pitch). A thicker piece of wood will be stiffer than a thin piece of wood of the same length.

i would say lower

does this have anything to do with the moment of inertia?

I would have been interested to see more examples relating to music this term.

I completely agree. I hadn't really thought about sounds/music as examples for approximation, but in some cases it may be more intuitive than some of the drag problems.

Can you explain "fundamental frequency"? Is it a important term to understanding this?

This is a somewhat weird angle for viewing the part.

I agree...while all the diagrams we have seen in past sections greatly contribute to having a better mental image, this one doesn't seem to bring as much to the table. If anything, using a diagram might trick the reader into thinking this experiment is more complex than it really is.

i think that a diagram is still useful, but it's hard to see how this is a plank. i also think there's not very much information being conveyed by 'hold' and 'tap.' perhaps the distances or other relevant dimensions should be marked.

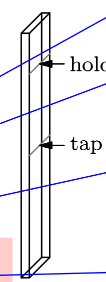
9.2 Musical tones

9.2.1 Wood blocks

Here is a home musical experiment that illustrates proportional reasoning and springs. First construct, or ask a carpenter or a local lumber yard to construct, two wood blocks made from the same larger wood plank. Mine have these dimensions:

1. 30 cm × 5 cm × 1 cm; and
2. 30 cm × 5 cm × 2 cm.

The blocks are identical except in their thickness: 2 cm vs 1 cm.



Now tap the thin block at the center while holding it lightly toward the edge, and listen to the musical note. If you do the same experiment to the thick block, will the pitch (fundamental frequency) be higher than, the same as, or lower than the pitch when you tapped the thin block?

You can answer this question in many ways. The first is to do the experiment. It would be nice either to predict the result before doing the experiment or to explain and understand the result after doing the experiment.

One argument is that the block is a resonant object, and the wavelength of the sound depends on the thickness of the block. In that picture, the thick block should have the longer wavelength and therefore the lower frequency. A counterargument, based on a different model of how the sound is made, is that the thick block is stiffer, so it vibrates faster. On the other hand, the thick block is more massive, so it vibrates more slowly. Perhaps these two effects – greater stiffness but greater mass – cancel each other, leaving the frequency unchanged?

I'll do the experiment right now and tell you the result. The thick block has a higher pitch. So the resonant-cavity model is probably wrong. Instead, the stiffness probably more than overcomes the mass.

A spring model explains this result and even predicts the frequency ratio. In the spring model, a wood block is made of wood atoms connected by

Also, will they actually be related? As in a third or fifth from each other, or is it random despite the almost-identicle dimensions?

Did you do this for us in 2.003? I kind of remember it with a metal ruler but I might be making it up

should be different right? kind of related to the stress factor of the board....like in tkd!

I thought it was cool in class when you said that some student could tell which block had the higher frequency just by hearing each block placed on a surface!

This brings up a point I hadn't considered before. How legitimate are these estimation predictions in proposing a scientific hypothesis?

I think the thicker one will produce a lower tone - no real solid reason why, but it feels right- you know?

I think that being able to predict is much better than explaining the result. Predicting demonstrates a true understanding of the physics, whereas any result can be backtracked and justified. Understanding the results is better than nothing though.

I think that being able to predict is much better than explaining the result. Predicting demonstrates a true understanding of the physics, whereas any result can be backtracked and justified. Understanding the results is better than nothing though.

In this case, a random prediction has a 1/2 chance of being correct, whereas understanding the results yields a much higher chance of know what caused them.

I think either method works fine. The main idea is that we apply to our understanding of the world to our observations.

I think also it would be nice if we could think about a slightly different scenario of this problem like knocking on a very thick door and a thin one and comparing the sounds.

I was going to comment on the wording in this sentence; shouldn't there be a 'however' or similar in the beginning of this sentence?

I think there should be...

resonant object could be defined.

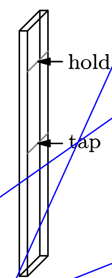
9.2 Musical tones

9.2.1 Wood blocks

Here is a home musical experiment that illustrates proportional reasoning and springs. First construct, or ask a carpenter or a local lumber yard to construct, two wood blocks made from the same larger wood plank. Mine have these dimensions:

1. 30 cm × 5 cm × 1 cm; and
2. 30 cm × 5 cm × 2 cm.

The blocks are identical except in their thickness: 2 cm vs 1 cm.



Now tap the thin block at the center while holding it lightly toward the edge, and listen to the musical note. If you do the same experiment to the thick block, will the pitch (fundamental frequency) be higher than, the same as, or lower than the pitch when you tapped the thin block?

You can answer this question in many ways. The first is to do the experiment. It would be nice either to predict the result before doing the experiment or to explain and understand the result after doing the experiment.

One argument is that the block is a resonant object, and the wavelength of the sound depends on the thickness of the block. In that picture, the thick block should have the longer wavelength and therefore the lower frequency. A counterargument, based on a different model of how the sound is made, is that the thick block is stiffer, so it vibrates faster. On the other hand, the thick block is more massive, so it vibrates more slowly. Perhaps these two effects – greater stiffness but greater mass – cancel each other, leaving the frequency unchanged?

I'll do the experiment right now and tell you the result. The thick block has a higher pitch. So the resonant-cavity model is probably wrong. Instead, the stiffness probably more than overcomes the mass.

A spring model explains this result and even predicts the frequency ratio. In the spring model, a wood block is made of wood atoms connected by

I guess because I immediately assumed thicker block = more stiffness, and guessed correctly, it's hard for me to understand some of the counter argument. In particular, what is the logic that a thicker block would mean a longer wavelength?

this is unnecessary considering the picture doesn't explain anything.

The picture maybe should show the 2 blocks, and why the wavelengths would change depending on thickness. (or a diagram to show the effects of the different proposed models, this is something I always have a hard time visualizing)

why isn't this part right? This is what came to mind in class.

It seems to be that the increased stiffness outweighs the other differences.

what if the other two dimensions are also not the same? how would you then compare the wavelength? does the wavelength only depend on the thickness?

Ah, in class today we're going to look at a xylophone and answer that very question.

this is what I originally thought. maybe the reason that the thicker block has a higher not is because it's easier to travel trough the block than through the air so the frequency is higher from the thick wood?

I thought the opposite but when I tried to reason through it I couldn't come up wit ha great answer. I'm assuming in a page or two I'll have my reason

yeah this is how I originally thought about the problem when we were doing the experiment in class.

How can you determine that the thick block is stiffer? I think it might be helpful to add a equation or explain the context of stiffness in greater detail.

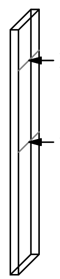
9.2 Musical tones

9.2.1 Wood blocks

Here is a home musical experiment that illustrates proportional reasoning and springs. First construct, or ask a carpenter or a local lumber yard to construct, two wood blocks made from the same larger wood plank. Mine have these dimensions:

1. $30\,\text{cm} \times 5\,\text{cm} \times 1\,\text{cm}$; and
2. $30\,\text{cm} \times 5\,\text{cm} \times 2\,\text{cm}$.

The blocks are identical except in their thickness: 2 cm vs 1 cm.



Now tap the thin block at the center while holding it lightly toward the edge, and listen to the musical note. If you do the same experiment to the thick block, will the pitch (fundamental frequency) be higher than, the same as, or lower than the pitch when you tapped the thin block?

You can answer this question in many ways. The first is to do the experiment. It would be nice either to predict the result before doing the experiment or to explain and understand the result after doing the experiment.

One argument is that the block is a resonant object, and the wavelength of the sound depends on the thickness of the block. In that picture, the thick block should have the longer wavelength and therefore the lower frequency. A counterargument, based on a different model of how the sound is made, is that the thick block is stiffer, so it vibrates faster. On the other hand, the thick block is more massive, so it vibrates more slowly. Perhaps these two effects – greater stiffness but greater mass – cancel each other, leaving the frequency unchanged?

I'll do the experiment right now and tell you the result. The thick block has a higher pitch. So the resonant-cavity model is probably wrong. Instead, the stiffness probably more than overcomes the mass.

A spring model explains this result and even predicts the frequency ratio. In the spring model, a wood block is made of wood atoms connected by

i often think to myself something along these lines and confuse myself. i specifically remember this happening a lot on the diagnostic.

I'm not an expert in material science but is this an appropriate model to use for wood?

I thought of the blocks by the first method mentioned. What is a good way to train intuition to use the spring/stiffness method above?

I intuitively used the spring model based on experience with metals of various thickness, however I think the point here is that it's really hard to tell what the right answer is here just using intuition, without doing any calculations.

Just like everyone who commented before me, I have the wrong intuition for thinking about this. I thought that the thicker wood has a longer wavelength, so lower pitch. I need to fix my intuition

I think my source of intuition for this problem was using a xylophone. On a xylophone, the longer bars correspond to low notes, so I just figured more wood = lower pitch.

(addendum: but I guess thickness and size don't exactly correspond well? hm...)

Yea so I had the same wavelengths thoughts, and I also thought about knocking on a wood door and I remember that sound as being lower than the first thin block we heard, but I guess maybe a door is too big to compare to the blocks.

Don't feel bad! When I ask this question in talks I give at physics departments, most of the faculty expect the thicker block to have the lower pitch (because thicker means longer wavelength).

This didn't cross my mind at all. I feel like when it comes to stiffness, the density/mass of the wood overwhelms the effects on the vibrations. My feeling is the stiffness difference is very minute compared to the difference in mass.

I don't understand how stiffness is related to vibration speed. I remember hearing this in class, but we never went over the reasoning.

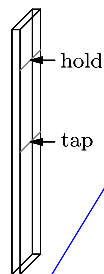
9.2 Musical tones

9.2.1 Wood blocks

Here is a home musical experiment that illustrates proportional reasoning and springs. First construct, or ask a carpenter or a local lumber yard to construct, two wood blocks made from the same larger wood plank. Mine have these dimensions:

1. 30 cm × 5 cm × 1 cm; and
2. 30 cm × 5 cm × 2 cm.

The blocks are identical except in their thickness: 2 cm vs 1 cm.



Now tap the thin block at the center while holding it lightly toward the edge, and listen to the musical note. If you do the same experiment to the thick block, will the pitch (fundamental frequency) be higher than, the same as, or lower than the pitch when you tapped the thin block?

You can answer this question in many ways. The first is to do the experiment. It would be nice either to predict the result before doing the experiment or to explain and understand the result after doing the experiment.

One argument is that the block is a resonant object, and the wavelength of the sound depends on the thickness of the block. In that picture, the thick block should have the longer wavelength and therefore the lower frequency. A counterargument, based on a different model of how the sound is made, is that the thick block is stiffer, so it vibrates faster. On the other hand, the thick block is more massive, so it vibrates more slowly. Perhaps these two effects – greater stiffness but greater mass – cancel each other, leaving the frequency unchanged?

I'll do the experiment right now and tell you the result. The thick block has a higher pitch. So the resonant-cavity model is probably wrong. Instead, the stiffness probably more than overcomes the mass.

A spring model explains this result and even predicts the frequency ratio. In the spring model, a wood block is made of wood atoms connected by

I really like that you give a reasoning for each possible argument, it allows each reader to hear a reasonable answer and make their hypothesis before you tell us what prediction is right. It makes even a book seem interactive!

yeah I agree...it was really helpful because the first argument was exactly what I had thought about in class on Monday...then it was interesting to read about the second argument as a reason for the frequencies to be the same, since I had originally eliminated this possibility without thinking about it very much.

When we say it vibrates faster, does that imply that the amplitude of this motion is smaller? Because when I imagine a thicker, stiffer block, I would assume that it wouldn't move as much in starting amplitude as would a thinner block, and since it says here that the thicker block vibrates faster, I thought that this implied that its starting amplitude was consequently smaller.

There's a difference between frequency and amplitude. Here we are talking about frequency. sin(theta) and 2*sin(theta) have different amplitudes but the same frequency for example.

you're right the thicker block will be harder to move, which means it will try to return to it's initial, lowest energy, position faster.

right, so that's an indication of frequency, and not amplitude. amplitude is only how loud the sound is, not what pitch it is at.

To be fair, it should in fact have lower amplitude (in addition to higher frequency), assuming you instill the same amount of energy when you tap it.

(since energy increases with both frequency and amplitude, if we increase one we need to decrease the other to keep the energy the same)

Since we are comparing mass and stiffness..please add a equation

I do not think this is the case just looking at things like a xylophone where the slats have slightly different lengths and they change frequency so I think that they would be different

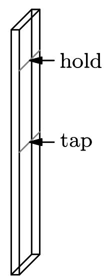
9.2 Musical tones

9.2.1 Wood blocks

Here is a home musical experiment that illustrates proportional reasoning and springs. First construct, or ask a carpenter or a local lumber yard to construct, two wood blocks made from the same larger wood plank. Mine have these dimensions:

1. 30 cm × 5 cm × 1 cm; and
2. 30 cm × 5 cm × 2 cm.

The blocks are identical except in their thickness: 2 cm vs 1 cm.



Now tap the thin block at the center while holding it lightly toward the edge, and listen to the musical note. If you do the same experiment to the thick block, will the pitch (fundamental frequency) be higher than, the same as, or lower than the pitch when you tapped the thin block?

You can answer this question in many ways. The first is to do the experiment. It would be nice either to predict the result before doing the experiment or to explain and understand the result after doing the experiment.

One argument is that the block is a resonant object, and the wavelength of the sound depends on the thickness of the block. In that picture, the thick block should have the longer wavelength and therefore the lower frequency. A counterargument, based on a different model of how the sound is made, is that the thick block is stiffer, so it vibrates faster. On the other hand, the thick block is more massive, so it vibrates more slowly. Perhaps these two effects – greater stiffness but greater mass – cancel each other, leaving the frequency unchanged?

I'll do the experiment right now and tell you the result. The thick block has a higher pitch. So the resonant-cavity model is probably wrong. Instead, the stiffness probably more than overcomes the mass.

A spring model explains this result and even predicts the frequency ratio. In the spring model, a wood block is made of wood atoms connected by

I would be surprised if everything canceled. That was the first answer choice that I eliminated in class.

So many other factors have canceled in previous examples that I think it is fair to include that here.

I feel like this should be reworded to something along the lines of "leaving the frequency of the two blocks the same".

It always surprises me how frequently these extra factors seem to cancel themselves out, when it seems so unlikely. However I think it's still a valid hypothesis worth suggesting, even if it doesn't seem very probable.

I like how this paragraph is almost determined to confuse the reader. It gives the analysis more credit knowing that the reader is unsure of what to expect.

This is the exact mental thought process i went though, but until you did the demo in class (and since i already knew the answer) i already knew which term wins out...but still cool!

damn! I was wrong

I would have guessed the thickness of the block outweighed the stiffness, making it a lower pitch

I agree. Prior to the experiment in class, my initial thought was that it was lower. Very much counter-intuitive.

When I heard the problem, I first thought of bending beams and their stiffness. Perhaps because I've taken 2.001 and 2.671. Is it possible that these blocks have harmonics from other bending modes?

I'm not sure if you've taken 2.002, but that class actually derives the physics of this situation. There was one lab where we actually used the frequency of a cantilever beam oscillations to calculate the pitch that would be generated when striking the object.

does the validity of the models depend on the delta magnitude of the thickness?

which model was this? i'm confused by the terminology.

I agree. Resonant-cavity??

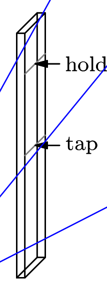
9.2 Musical tones

9.2.1 Wood blocks

Here is a home musical experiment that illustrates proportional reasoning and springs. First construct, or ask a carpenter or a local lumber yard to construct, two wood blocks made from the same larger wood plank. Mine have these dimensions:

1. 30 cm × 5 cm × 1 cm; and
2. 30 cm × 5 cm × 2 cm.

The blocks are identical except in their thickness: 2 cm vs 1 cm.



Now tap the thin block at the center while holding it lightly toward the edge, and listen to the musical note. If you do the same experiment to the thick block, will the pitch (fundamental frequency) be higher than, the same as, or lower than the pitch when you tapped the thin block?

You can answer this question in many ways. The first is to do the experiment. It would be nice either to predict the result before doing the experiment or to explain and understand the result after doing the experiment.

One argument is that the block is a resonant object, and the wavelength of the sound depends on the thickness of the block. In that picture, the thick block should have the longer wavelength and therefore the lower frequency. A counterargument, based on a different model of how the sound is made, is that the thick block is stiffer, so it vibrates faster. On the other hand, the thick block is more massive, so it vibrates more slowly. Perhaps these two effects – greater stiffness but greater mass – cancel each other, leaving the frequency unchanged?

I'll do the experiment right now and tell you the result. The thick block has a higher pitch. So the resonant-cavity model is probably wrong. Instead, the stiffness probably more than overcomes the mass.

A spring model explains this result and even predicts the frequency ratio. In the spring model, a wood block is made of wood atoms connected by

Should the fact that we're calling it a resonant _cavity_ be a clue that it is an incorrect model, as we are dealing with the presence of matter (the wood block) rather than the absence (a cavity)?

I think the reason why he keeps calling it a resonant-cavity is that resonant cavities can be modelled using any physical resonator such as an RLC circuit. So maybe the term just refers to a general resonator? maybe?

yeah i was a little confused by this wording too...

Would not have thought this

Me neither, but I still wasn't sure enough to have thought the other answer was correct.

I don't think I would know where to start when trying to come up with this on my own.

I definitely didnt know where to start on this one, but my gut told me to guess higher. I'm excited to see the explanation for this

This is a little confusing because I don't know how to connect the models you proposed your results (most likely due to terminology)

this is an awkward sentence. we did the experiment so "probably" seems a little strange here. we know it's higher for some reason, and the stiffness was our logical argument.

Probably? If the results of the experiment are as you say, why "probably?"

We haven't come up with any mathematical justification for it yet. Thus, we can't assume that because A is false, B is true. The experiment must be examined.

False can imply everything, as we know. If 1 = 2, the I'm the pope.

Are we expected to know that springs model this situation well? You just sort of declare that springs work well in this situation, but I would have no idea if that is true or not.

I think he is first making the statement and then explains it afterward

I agree that this transition is sudden. It seems you were discussing two models in the preceding paragraph and it feels like you've discarded them.

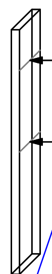
9.2 Musical tones

9.2.1 Wood blocks

Here is a home musical experiment that illustrates proportional reasoning and springs. First construct, or ask a carpenter or a local lumber yard to construct, two wood blocks made from the same larger wood plank. Mine have these dimensions:

1. 30 cm × 5 cm × 1 cm; and
2. 30 cm × 5 cm × 2 cm.

The blocks are identical except in their thickness: 2 cm vs 1 cm.



Now tap the thin block at the center while holding it lightly toward the edge, and listen to the musical note. If you do the same experiment to the thick block, will the pitch (fundamental frequency) be higher than, the same as, or lower than the pitch when you tapped the thin block?

You can answer this question in many ways. The first is to do the experiment. It would be nice either to predict the result before doing the experiment or to explain and understand the result after doing the experiment.

One argument is that the block is a resonant object, and the wavelength of the sound depends on the thickness of the block. In that picture, the thick block should have the longer wavelength and therefore the lower frequency. A counterargument, based on a different model of how the sound is made, is that the thick block is stiffer, so it vibrates faster. On the other hand, the thick block is more massive, so it vibrates more slowly. Perhaps these two effects – greater stiffness but greater mass – cancel each other, leaving the frequency unchanged?

I'll do the experiment right now and tell you the result. The thick block has a higher pitch. So the resonant-cavity model is probably wrong. Instead, the stiffness probably more than overcomes the mass.

A spring model explains this result and even predicts the frequency ratio. In the spring model, a wood block is made of wood atoms connected by

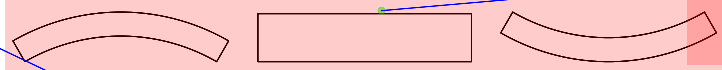
Awesome phrase. You might want to call attention to it like you did in class just to point out that you're aware that wood is not an element..

Haha, I like this idea of wood atoms.

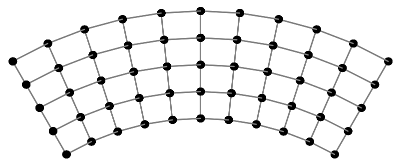
I was confused by this in class - how would this model work? how do you know how many "atoms" contribute to the spring ?

it's not a matter of how many, it's just the fact that the atoms are constantly moving creating a spring-like motion and response.

chemical bonds, which are springs. As the block vibrates, it takes these shapes (shown in a side view):



The block is made of springs, and it acts like a big spring. The middle position is the equilibrium position, when the block has zero potential energy and maximum kinetic energy. The potential energy is stored in stretching and compressing the bonds. Imagine deforming the block into a shape like the first shape:



Each dot is a wood 'atom', and each gray line is a spring that models the chemical bond between wood atoms. Deforming the block stretches and compresses these bonds. These numerous individual springs combine to make the block behave like a large spring. Because the block is a big spring, the energy required to to produce a vertical deflection is proportional to the square of the deflection:

$$E \sim ky^2, \tag{9.20}$$

where y is the deflection, and k is the stiffness of the block.

Intuitively, the thicker the block, the stiffer it is (higher k). The spring model will help us find how k depends on the thickness h. To do so, imagine deflecting the thin and thick blocks by the same distance y, then compare their stored energies E_{thin} and E_{thick} by forming their ratio

$$\frac{E_{\text{thick}}}{E_{\text{thin}}}. \tag{9.21}$$

That ratio is

$$\frac{k_{\text{thick}}y^2}{k_{\text{thin}}y^2} = \frac{k_{\text{thick}}}{k_{\text{thin}}} \tag{9.22}$$

because y is the same for the thick and thin blocks. So, the ratio of stored energies is also the ratio of stiffnesses.

Surely, these are extreme examples.

Well I think he wanted to show the block when it has zero PE and max KE (the middle picture), and the block when it has max PE and zero KE (the left and right pictures), which is why he chose these three "extreme" examples.

Without extreme examples we wouldn't be able to see the motion. Also, depending on what block we use (a yard stick for example) these examples would be much less extreme.

Agreed- if he showed us the actual shape changes for this example, we wouldn't be able to tell (or if we could, it would be extremely difficult). I like the extreme cases because they are easy to distinguish.

Yeah, although they aren't that realistic, they are useful for getting the point across and I like the figure. I also like how you apply it to the Figure below.

This might just be me nit-picking, but it bothers me that the blocks on the right and the left are different widths than the block in the center, it makes it hard for me to think that they are the same block.

we are making the assumption of only a single mode oscillation in the system here?

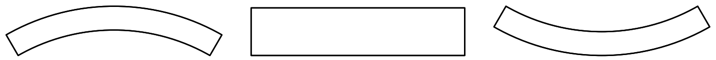
The way it is being held wipes out most of the other possibilities (any mode that doesn't have a node where your finger is will get damped out as it tries to move your finger, which is squishy). The surviving modes (in what is called a "pinned-pinned beam") all turn out to have frequencies that are integer multiples of the fundamental. So you hear them as coloration ("timbre" is the official word) on the fundamental. Timbre (the overtone amplitudes) is the difference between a xylophone sound and a piano playing the same fundamental frequency.

I'm surprised that the wood can bend this much.

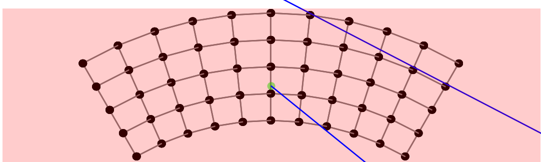
I don't think it can. It's just to really accentuate what is occurring in the wood.

This are good pictures. Coupled with the diagram of the lattice below of the wood atoms, it is definitely a nice aid to the reading (though the reading is fairly straightforward here).

chemical bonds, which are springs. As the block vibrates, it takes these shapes (shown in a side view):



The block is made of springs, and it acts like a big spring. The middle position is the equilibrium position, when the block has zero potential energy and maximum kinetic energy. The potential energy is stored in stretching and compressing the bonds. Imagine deforming the block into a shape like the first shape:



Each dot is a wood 'atom', and each gray line is a spring that models the chemical bond between wood atoms. Deforming the block stretches and compresses these bonds. These numerous individual springs combine to make the block behave like a large spring. Because the block is a big spring, the energy required to to produce a vertical deflection is proportional to the square of the deflection:

$$E \sim ky^2, \tag{9.20}$$

where y is the deflection, and k is the stiffness of the block.

Intuitively, the thicker the block, the stiffer it is (higher k). The spring model will help us find how k depends on the thickness h. To do so, imagine deflecting the thin and thick blocks by the same distance y, then compare their stored energies E_{thin} and E_{thick} by forming their ratio

$$\frac{E_{\text{thick}}}{E_{\text{thin}}}. \tag{9.21}$$

That ratio is

$$\frac{k_{\text{thick}} y^2}{k_{\text{thin}} y^2} = \frac{k_{\text{thick}}}{k_{\text{thin}}} \tag{9.22}$$

because y is the same for the thick and thin blocks. So, the ratio of stored energies is also the ratio of stiffnesses.

The "middle" just refers to where you hit it right?

I think the middle refers literally to the middle, the position that doesn't change during vibration.

I thought he was referring to the middle picture...

Yeah, definitely the picture. Although I guess he could make it less confusing.

Yeah I'm also thought that this was referring to the middle picture in the Figure. I think it has to be since a single point on the block can't be when the block itself has zero potential energy. It has to be a state of the block,which is unbent, to be described like that.

perhaps "neutral" is better terminology here.

with a very very high spring constant

Yes, this seems like a stretch of a comparison. Stiff board = spring..?

doesn't kinetic energy imply motion though?

This section is very well written. I had no problem following the explanation in the paragraphs and the figures add a lot to the reading.

So far this section has been very explicit and easy to follow...due to the pictures and clear emphasis on what is being tested.

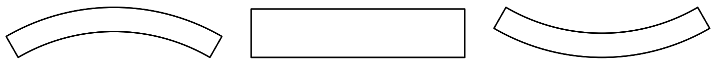
Yeah! And it's been especially easy to follow because we saw this example in class.

will you touch on simple beam theory at all in this example and compare it to the use of springs?

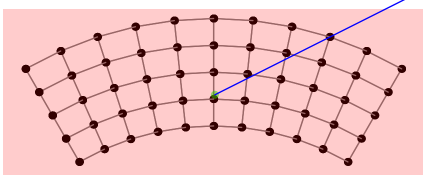
This has been the most helpful diagram and explanation for me in a long time.

so then maybe more of the energy is transferred to the thicker block given the sounds from it a higher frequency? If you could hold the blocks more rigidly would the thicker block then have a lower frequency?

chemical bonds, which are springs. As the block vibrates, it takes these shapes (shown in a side view):



The block is made of springs, and it acts like a big spring. The middle position is the equilibrium position, when the block has zero potential energy and maximum kinetic energy. The potential energy is stored in stretching and compressing the bonds. Imagine deforming the block into a shape like the first shape:



Each dot is a wood 'atom', and each gray line is a spring that models the chemical bond between wood atoms. Deforming the block stretches and compresses these bonds. These numerous individual springs combine to make the block behave like a large spring. Because the block is a big spring, the energy required to to produce a vertical deflection is proportional to the square of the deflection:

$$E \sim ky^2, \tag{9.20}$$

where y is the deflection, and k is the stiffness of the block.

Intuitively, the thicker the block, the stiffer it is (higher k). The spring model will help us find how k depends on the thickness h. To do so, imagine deflecting the thin and thick blocks by the same distance y, then compare their stored energies E_{thin} and E_{thick} by forming their ratio

$$\frac{E_{\text{thick}}}{E_{\text{thin}}}. \tag{9.21}$$

That ratio is

$$\frac{k_{\text{thick}}y^2}{k_{\text{thin}}y^2} = \frac{k_{\text{thick}}}{k_{\text{thin}}} \tag{9.22}$$

because y is the same for the thick and thin blocks. So, the ratio of stored energies is also the ratio of stiffnesses.

this pic is very helpful to me.

I too, like this drawing, but if you just presented us this and said "figure it out now, using springs", i would be very confused, and have even less intuition about what to do next than when i wasn't given this picture. This system looks very complicated and rather intimidating.

I don't really see how this relates to springs, but as a picture of atoms I can see how this framework would behave

The connections between "atoms" have to be springy for this diagram to work. They can't just be rigid rods.

I think the point is that the chemical bond between each 'wood' atom is the same, but the outer ones are stretched which is why they are springy

I really like this diagram

I found this to be nice as well, it was very simple and helped to explain the problem.

Are there really no other complications we would have to deal with ? are we assuming the atoms have no mass?

Can we really assume this? The springs act in two different dimensions, and as the commenter before me mentioned, atoms do have mass (and the springs would have mass too...).

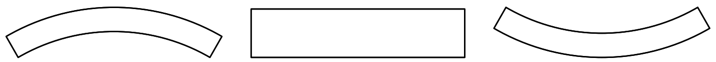
I think it's fine. Springs in every mechanics course are treated to be massless.

I think it goes back to the fundamental part of the class, which is that you have to assume something to get an answer. I think this is definitely within reason.

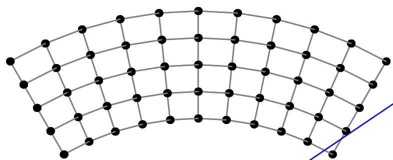
The atoms definitely have mass: That's the mass that the springs must move. So, more atoms (thicker block) means it is harder to vibrate. On the other hand (as you find later), the thicker block has a lot more spring stretch (in the bonds), and that effect more than makes up for the extra mass to be moved.

Typo.

chemical bonds, which are springs. As the block vibrates, it takes these shapes (shown in a side view):



The block is made of springs, and it acts like a big spring. The middle position is the equilibrium position, when the block has zero potential energy and maximum kinetic energy. The potential energy is stored in stretching and compressing the bonds. Imagine deforming the block into a shape like the first shape:



Each dot is a wood 'atom', and each gray line is a spring that models the chemical bond between wood atoms. Deforming the block stretches and compresses these bonds. These numerous individual springs combine to make the block behave like a large spring. Because the block is a big spring, the energy required to to produce a vertical deflection is proportional to the square of the deflection:

$$E \sim ky^2, \tag{9.20}$$

where y is the deflection, and k is the stiffness of the block.

Intuitively, the thicker the block, the stiffer it is (higher k). The spring model will help us find how k depends on the thickness h. To do so, imagine deflecting the thin and thick blocks by the same distance y, then compare their stored energies E_{thin} and E_{thick} by forming their ratio

$$\frac{E_{\text{thick}}}{E_{\text{thin}}}. \tag{9.21}$$

That ratio is

$$\frac{k_{\text{thick}}y^2}{k_{\text{thin}}y^2} = \frac{k_{\text{thick}}}{k_{\text{thin}}} \tag{9.22}$$

because y is the same for the thick and thin blocks. So, the ratio of stored energies is also the ratio of stiffnesses.

Seems like you were describing it as a lot of smaller springs?

Yeah, the chemical bonds between "wood atoms" are springs, as we've established already, so here we're saying that all these individual springs make the combined wood block like one big spring

Is deflection a function of position in this case?

I believe we're looking at deflection of the end of the block, but measuring the deflection anywhere else would only change the constant of proportionality, not the underlying behavior.

Yes, that makes sense. Deflection, or position of a given point in the block relative to equilibrium defines the same relationship with stored energy.

I don't get how we got this

I just compared these variables' dimensions. Since we're talking about springs, I saw the block's stiffness to serve as the spring constant.

[E] = J = M*L^2*T^-2 [k] = M*T^-2 [y] = L

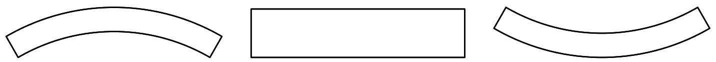
good thinking! This break down may be a good idea to include in the passage for those more unfamiliar with springs or physics in general.

Smart, Springs have stiffness, and so does wood. Therefore, their frequency = sqrt(k/m). Now I understand why the thicker (aka stiffer) wood has higher frequency and thus higher pitch. This is one of thecoolest things I have learned

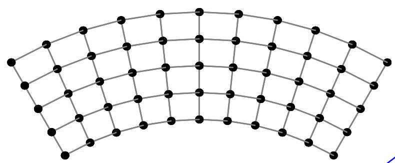
I wouldn't have thought of this on my own, but after seeing it, it makes a lot of sense.

Same here, it makes so much sense and agreed with intuition but was a little past where I was able to explore the problem.

chemical bonds, which are springs. As the block vibrates, it takes these shapes (shown in a side view):



The block is made of springs, and it acts like a big spring. The middle position is the equilibrium position, when the block has zero potential energy and maximum kinetic energy. The potential energy is stored in stretching and compressing the bonds. Imagine deforming the block into a shape like the first shape:



Each dot is a wood 'atom', and each gray line is a spring that models the chemical bond between wood atoms. Deforming the block stretches and compresses these bonds. These numerous individual springs combine to make the block behave like a large spring. Because the block is a big spring, the energy required to to produce a vertical deflection is proportional to the square of the deflection:

$$E \sim ky^2, \tag{9.20}$$

where y is the deflection, and k is the stiffness of the block.

Intuitively, the thicker the block, the stiffer it is (higher k). The spring model will help us find how k depends on the thickness h. To do so, imagine deflecting the thin and thick blocks by the same distance y, then compare their stored energies E_{thin} and E_{thick} by forming their ratio

$$\frac{E_{\text{thick}}}{E_{\text{thin}}}. \tag{9.21}$$

That ratio is

$$\frac{k_{\text{thick}}y^2}{k_{\text{thin}}y^2} = \frac{k_{\text{thick}}}{k_{\text{thin}}} \tag{9.22}$$

because y is the same for the thick and thin blocks. So, the ratio of stored energies is also the ratio of stiffnesses.

Is this like U = .5kx^2 for normal springs?

I am confused here; why not having it relate to a deflection angle? Depending on where you are, the deflection is different, no?

I'm thinking of the block as a black box (an abstraction!). You push on it, and it pushes back (like a spring would). The question is how hard it pushes back for a given deflection, however that deflection is measured. The "how hard per deflection" is the spring constant.

(To answer the original post: Right, the ky^2 is just the U=kx^2/2 for a spring, but dropping the factor of 2 because 1=2 in this course.)

maybe you should explain how to test for stiffness. if you think about testing for stiffness, its related to how much deflection you see compared to the force you are applying.....and you can measure force applied on a spring scale. so yes, it is like hookes law, right?

Could you maybe explain the derivation of this equation? or origin?

I think of k as a youngs modulus of sorts- and that does not change with thickness it independent of size and shape

isn't EACH of the k's for each of the springs the same? b/c it is the same material. there are just more rows of k's, so the effective k is higher.

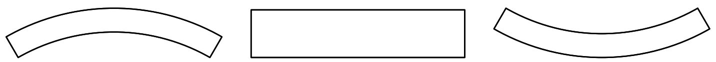
That sound right, but he's just talking about the "combined" spring, or the 'effective' spring. If we think of the whole block as one spring, then it has only 1 k, which just happens to be a combination of the individual ks.

I agree, think about what happens on the macro scale when you add springs in parallel, the effective stiffness increases.

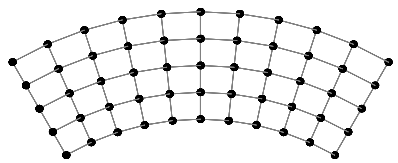
Also it makes sense that the thickness of the wood is the dimension we care about since the "springs" stretched during perturbations are the horizontal ones. So thicker wood means more horizontal springs.

to the original commenter, you're assuming k is an intensive property, which it isn't. (It's not an extensive property either – in fact, it works fairly similarly to conductance, the inverse of resistance.)

chemical bonds, which are springs. As the block vibrates, it takes these shapes (shown in a side view):



The block is made of springs, and it acts like a big spring. The middle position is the equilibrium position, when the block has zero potential energy and maximum kinetic energy. The potential energy is stored in stretching and compressing the bonds. Imagine deforming the block into a shape like the first shape:



Each dot is a wood 'atom', and each gray line is a spring that models the chemical bond between wood atoms. Deforming the block stretches and compresses these bonds. These numerous individual springs combine to make the block behave like a large spring. Because the block is a big spring, the energy required to to produce a vertical deflection is proportional to the square of the deflection:

$$E \sim ky^2, \quad (9.20)$$

where y is the deflection, and k is the stiffness of the block.

Intuitively, the thicker the block, the stiffer it is (higher k). The spring model will help us find how k depends on the thickness h. To do so, imagine deflecting the thin and thick blocks by the same distance y, then compare their stored energies E_{thin} and E_{thick} by forming their ratio

$$\frac{E_{\text{thick}}}{E_{\text{thin}}}. \quad (9.21)$$

That ratio is

$$\frac{k_{\text{thick}} y^2}{k_{\text{thin}} y^2} = \frac{k_{\text{thick}}}{k_{\text{thin}}} \quad (9.22)$$

because y is the same for the thick and thin blocks. So, the ratio of stored energies is also the ratio of stiffnesses.

How do we know that tapping the blocks leads to the same deflection?

It doesn't matter! For two reasons. First, one can tap them in such a way that the deflections are the same. Second, even if that isn't true, frequency is independent of amplitude (the key feature of simple harmonic motion). So, we can assume any amplitude we want and get a frequency, and it'll be the same for all amplitudes. Every time I run across this SHM property, I am surprised.

This is such a better example then the planets in the last reading

This section is very clear but I don't know if it follows with the rest of the text. There are much more intense assumptions that are made in the rest of the readings while this is a very simple thing to understand and is very explicitly stated.

I think that's good though. This is explaining and illustrating how spring models work. It wouldn't help much if we were confused while reading it.

why is the deflection the same for the thin and thick blocks? Is it that the amplitude is determined by the input force?

He said earlier that we're going to deflect the blocks the same amount.

It doesn't matter! For two reasons. First, one can tap them in such a way that the deflections are the same. Second, even if that isn't true, frequency is independent of amplitude (the key feature of simple harmonic motion). So, we can assume any amplitude we want and get a frequency, and it'll be the same for all amplitudes. Every time I run across this SHM property, I am surprised.

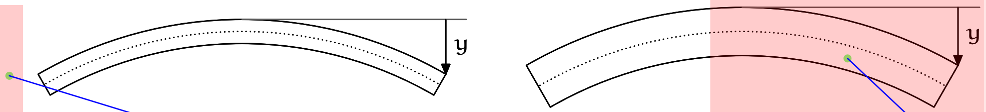
So energy is proportional to pitch? Higher energy -> higher pitch?

Yes, high energy <-> high frequency/pitch

and we can just ignore the added mass and other things addressed in the beginning? actuallly i guess he didnt ask us to predict how much the frequency would CHANGE, just which would be higher

This is a really good example - very clear and interesting. When you mentioned the ratio of energies, a lightbulb went off in my head, and it all made perfect sense.

To find the stored energies, look at this picture of the blocks, with the dotted line showing the neutral line (the line without compression or extension):



The deflection hardly changes the lengths of the radial-direction bond springs. However, the tangential springs (along the long length of the block) get extended or compressed. Above the neutral line the springs are extended. Below the neutral line, the springs are compressed. The amount of extension is proportional to the distance from the neutral line.

Now study comparable bond springs in the thin and thick blocks. Each spring in the thin block corresponds to a spring in the thick block that is twice as far away from the neutral line. The spring in the thick block has twice the extension (or compression) of its partner in the thin block. So the spring in the thick block stores four times the energy of its partner spring in the thin block. Furthermore, the thick block has twice as many layers as does the thin black, so each spring in the thin block has two partners, with identical extension, in the thick block. So the thick block stores eight times the energy of the thin block (for the same deflection y).

Thus

$$\frac{k_{\text{thick}}}{k_{\text{thin}}} = 8. \quad (9.23)$$

This factor of 8 results from multiplying the thickness by 2. In general, stiffness is proportional to the cube of the thickness:

$$k \propto h^3. \quad (9.24)$$

Because the entire wood block acts like a spring, its oscillation frequency is $\omega = \sqrt{k/m}$. The mass ratio is caused by the thickness ratio:

$$\frac{m_{\text{thick}}}{m_{\text{thin}}} = 2. \quad (9.25)$$

Because the stiffness ratio is 8, the frequency ratio is

$$\frac{\omega_{\text{thick}}}{\omega_{\text{thin}}} = \sqrt{\frac{8}{2}} = 2. \quad (9.26)$$

It's so interesting that this is your favorite demonstration.

then why is the dotted line bent??

it's that the material below the line is in compression, and the material above it is in tension. the neutral line is in neither compression or tension.

This is off topic- but these diagrams remind me of the pictures of illusions usually shown in psych classes...the one that comes to mind is the picture of 2 lines that are the same length but look different because of the direction of the arrows on each end (<——> and >——<).. for this diagram (at least to me), the y on the right looks bigger than the y on the left because of the different in the blocks, but they are actually the same!

this is a vry good picture to help understand what is happening

It might be nice to put the same diagram with the bond lines and dots here to go with this text. These two diagrams don't illustrate the concept as well.

i'm having trouble picturing this

Is he referring to the "neutral line"?

I think it would have been better to see the entire motion of each spring. It would make the explanation a little clearer.

i think it refers to the bonds across the thickness of the plank rather than the length (aka the 'radial' direction.)

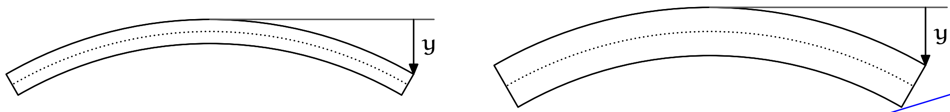
I feel like just tapping the block will not lead to a measurable deflection in the beam

I think you could explain a little more here... I am starting to get lost.

I don't really understand this scenario. Which springs are the radial direction springs? maybe detailing this in one of the figures would be helpful

The bent wood appears to be a piece of a circle (an arc), and the radially directed springs would be the ones along the radius of this circle. These springs would only come into play if the thickness of the board changed along its length.

To find the stored energies, look at this picture of the blocks, with the dotted line showing the neutral line (the line without compression or extension):



The deflection hardly changes the lengths of the radial-direction bond springs. However, the tangential springs (along the long length of the block) get extended or compressed. Above the neutral line the springs are extended. Below the neutral line, the springs are compressed. The amount of extension is proportional to the distance from the neutral line.

Now study comparable bond springs in the thin and thick blocks. Each spring in the thin block corresponds to a spring in the thick block that is twice as far away from the neutral line. The spring in the thick block has twice the extension (or compression) of its partner in the thin block. So the spring in the thick block stores four times the energy of its partner spring in the thin block. Furthermore, the thick block has twice as many layers as does the thin black, so each spring in the thin block has two partners, with identical extension, in the thick block. So the thick block stores eight times the energy of the thin block (for the same deflection y).

Thus

$$\frac{k_{\text{thick}}}{k_{\text{thin}}} = 8. \tag{9.23}$$

This factor of 8 results from multiplying the thickness by 2. In general, stiffness is proportional to the cube of the thickness:

$$k \propto h^3. \tag{9.24}$$

Because the entire wood block acts like a spring, its oscillation frequency is $\omega = \sqrt{k/m}$. The mass ratio is caused by the thickness ratio:

$$\frac{m_{\text{thick}}}{m_{\text{thin}}} = 2. \tag{9.25}$$

Because the stiffness ratio is 8, the frequency ratio is

$$\frac{\omega_{\text{thick}}}{\omega_{\text{thin}}} = \sqrt{\frac{8}{2}} = 2. \tag{9.26}$$

I'm kind of confused as to what we are comparing.

We're looking at how far our "springs" are stretched in each block for the same deflection

I feel like this section only makes sense to me because it reminds me of beam bending in 2.001, but otherwise I'd be confused since there is no diagram...

yeah I haven't taken 2.001 and I'm confused about this section..

I haven't taken 2.001, but it seemed pretty clear to me what this paragraph is talking about based on the previous diagram.

I'm a bit lost here...

I feel like this whole section could be a lot more easily understood with a few simple diagrams of the differences between the two blocks at the molecular level, instead of the existing images, which show only the macroscopic structural differences.

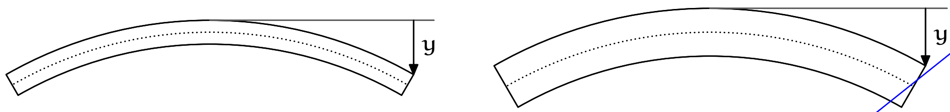
I agree, it would be nice to see the springs shows in the pictures as opposed to these images.

Definitely. And perhaps bullet points to show where each factor of 2 comes from, instead of hiding them in the paragraph.

Yeah I agree with the factors of two comment. I honestly came out of the paragraph not understanding where the 8 was coming from. I had to re-read the paragraph.

I agree with all the comments in this thread and will add many diagrams as a result. (My only defense is that you should have seen the reading in its state a few days ago, before I added many of the diagrams and improved other diagrams – because I knew it would be helpful based on earlier memos).

To find the stored energies, look at this picture of the blocks, with the dotted line showing the neutral line (the line without compression or extension):



The deflection hardly changes the lengths of the radial-direction bond springs. However, the tangential springs (along the long length of the block) get extended or compressed. Above the neutral line the springs are extended. Below the neutral line, the springs are compressed. The amount of extension is proportional to the distance from the neutral line.

Now study comparable bond springs in the thin and thick blocks. Each spring in the thin block corresponds to a spring in the thick block that is twice as far away from the neutral line. The spring in the thick block has twice the extension (or compression) of its partner in the thin block. So the spring in the thick block stores four times the energy of its partner spring in the thin block. Furthermore, the thick block has twice as many layers as does the thin black, so each spring in the thin block has two partners, with identical extension, in the thick block. So the thick block stores eight times the energy of the thin block (for the same deflection y).

Thus

$$\frac{k_{\text{thick}}}{k_{\text{thin}}} = 8. \tag{9.23}$$

This factor of 8 results from multiplying the thickness by 2. In general, stiffness is proportional to the cube of the thickness:

$$k \propto h^3. \tag{9.24}$$

Because the entire wood block acts like a spring, its oscillation frequency is $\omega = \sqrt{k/m}$. The mass ratio is caused by the thickness ratio:

$$\frac{m_{\text{thick}}}{m_{\text{thin}}} = 2. \tag{9.25}$$

Because the stiffness ratio is 8, the frequency ratio is

$$\frac{\omega_{\text{thick}}}{\omega_{\text{thin}}} = \sqrt{\frac{8}{2}} = 2. \tag{9.26}$$

Why would the spring in the thick block have twice the extension of a spring in the thin block? I would have guessed it's the other way around

I am also very confused by this.

This is confusing, could you include a diagram and point this stuff out? I think that could help a lot.

Take the case of a spring bond at the top edge of a block: This spring in the thick block is twice the distance from the neutral axis as that in the thin block. As he notes, the amount of extension is proportional to the distance from the neutral axis. This fact comes from looking at the radius of curvature and strain in the block. A decent derivation: <http://www.ecourses.ou.edu/cgi-bin/ebook.cgi?doc=&topic=me&chap_sec=04.1&am

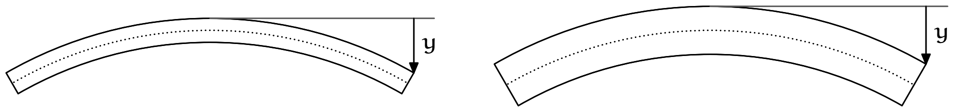
Ah, that makes sense! It would help to have that explained more explicitly. I feel like this section so far was good about going slowly and then this paragraph just kind of whirled by...

The thick block has twice as many "wood" atoms, so the springs should extend the same since there twice as many to span the doubled extension, no?

True there are more wood atoms, but in term of matching up atoms from the thin block with the thick block, atoms would be like "every other" one, hence twice as far.

ok, but how does that relate to 4 times the energy?

To find the stored energies, look at this picture of the blocks, with the dotted line showing the neutral line (the line without compression or extension):



The deflection hardly changes the lengths of the radial-direction bond springs. However, the tangential springs (along the long length of the block) get extended or compressed. Above the neutral line the springs are extended. Below the neutral line, the springs are compressed. The amount of extension is proportional to the distance from the neutral line.

Now study comparable bond springs in the thin and thick blocks. Each spring in the thin block corresponds to a spring in the thick block that is twice as far away from the neutral line. The spring in the thick block has twice the extension (or compression) of its partner in the thin block. So the spring in the thick block stores four times the energy of its partner spring in the thin block. Furthermore, the thick block has twice as many layers as does the thin black, so each spring in the thin block has two partners, with identical extension, in the thick block. So the thick block stores eight times the energy of the thin block (for the same deflection y).

Thus

$$\frac{k_{\text{thick}}}{k_{\text{thin}}} = 8. \tag{9.23}$$

This factor of 8 results from multiplying the thickness by 2. In general, stiffness is proportional to the cube of the thickness:

$$k \propto h^3. \tag{9.24}$$

Because the entire wood block acts like a spring, its oscillation frequency is $\omega = \sqrt{k/m}$. The mass ratio is caused by the thickness ratio:

$$\frac{m_{\text{thick}}}{m_{\text{thin}}} = 2. \tag{9.25}$$

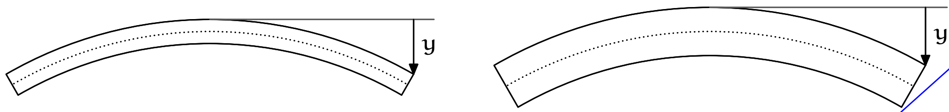
Because the stiffness ratio is 8, the frequency ratio is

$$\frac{\omega_{\text{thick}}}{\omega_{\text{thin}}} = \sqrt{\frac{8}{2}} = 2. \tag{9.26}$$

This point definitely needs a few diagrams to make it more intuitive (as suggested in a few other threads). Imagine pairing each spring in the thin block with a spring in the thick block that is twice as far from the neutral line. So, the neutral line maps to the neutral line; the outer edge maps to the outer edge (and same for the inner edge).

The next idea is that the spring's extension is proportional to distance from the neutral line. Think of each row as an arc of a circle. As you go outward from the neutral line, the radius of the arc increases linearly, as does the arc's length. But all the arcs have the same number of springs (or atoms) – that is determined by the unstretched length. So, the extra stretch, which is proportional to distance from the neutral line, is distributed over a fixed number of springs. Therefore, each spring's extension is proportional to the distance from the neutral line. (Which means that the energy stored in each spring is proportional to the square of the distance from the neutral line.)

To find the stored energies, look at this picture of the blocks, with the dotted line showing the neutral line (the line without compression or extension):



The deflection hardly changes the lengths of the radial-direction bond springs. However, the tangential springs (along the long length of the block) get extended or compressed. Above the neutral line the springs are extended. Below the neutral line, the springs are compressed. The amount of extension is proportional to the distance from the neutral line.

Now study comparable bond springs in the thin and thick blocks. Each spring in the thin block corresponds to a spring in the thick block that is twice as far away from the neutral line. The spring in the thick block has twice the extension (or compression) of its partner in the thin block. So the spring in the thick block stores four times the energy of its partner spring in the thin block. Furthermore, the thick block has twice as many layers as does the thin black, so each spring in the thin block has two partners, with identical extension, in the thick block. So the thick block stores eight times the energy of the thin block (for the same deflection y).

Thus

$$\frac{k_{\text{thick}}}{k_{\text{thin}}} = 8. \tag{9.23}$$

This factor of 8 results from multiplying the thickness by 2. In general, stiffness is proportional to the cube of the thickness:

$$k \propto h^3. \tag{9.24}$$

Because the entire wood block acts like a spring, its oscillation frequency is $\omega = \sqrt{k/m}$. The mass ratio is caused by the thickness ratio:

$$\frac{m_{\text{thick}}}{m_{\text{thin}}} = 2. \tag{9.25}$$

Because the stiffness ratio is 8, the frequency ratio is

$$\frac{\omega_{\text{thick}}}{\omega_{\text{thin}}} = \sqrt{\frac{8}{2}} = 2. \tag{9.26}$$

i don't have this entirely clear in my head yet, but i think there's a second moment of inertia that has something to do with this.

Yes, this paragraph goes by much too fast. I think you could add some information to the picture above to make it more clear, perhaps. I'm not entirely sure, for example, why twice the extension leads to 4 times the energy.

The energy stored in a spring is 1/2*K*x^2. If you displace it by twice some reference displacement, you get (2x)^2 –> 4x^2, which when plugged in to the energy formula gets four times the reference energy.

I think it would be helpful to have that formula for the energy stored in a spring in the actual text for those students who have forgotten some 8.01.

I agree, this paragraph needs some diagrams or more step by step equations showing relationships between quantities/proportionality

I agree about the spring energy storage, for non course 2 people this might not be information readily stored in one's head

Yeah, this paragraph was pretty confusing for a non-course 2 person. Specifically I'm confused on the jump from 4 to 8 times more energy... could you explain the bit about each spring has 2 partners?

If both springs are displaced by the same amount as shown in the picture above, why would there be a factor of 8?

I disagree. This was very clear. It was definitely a 'wow' moment. Very good explanation.

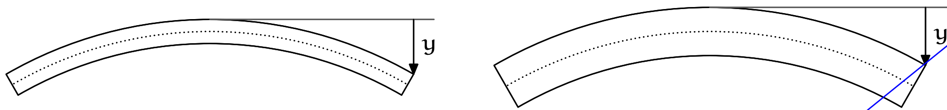
This strikes me as a little hand-wavey. I get it, I think, but it wouldn't necessarily make sense if I hadn't taken 2.001

it feels like the distance and the double layers is counting the same thing twice. can we go over how they are different?

should be "block"

all the 'thin' and 'thick' words are confusing me

To find the stored energies, look at this picture of the blocks, with the dotted line showing the neutral line (the line without compression or extension):



The deflection hardly changes the lengths of the radial-direction bond springs. However, the tangential springs (along the long length of the block) get extended or compressed. Above the neutral line the springs are extended. Below the neutral line, the springs are compressed. The amount of extension is proportional to the distance from the neutral line.

Now study comparable bond springs in the thin and thick blocks. Each spring in the thin block corresponds to a spring in the thick block that is twice as far away from the neutral line. The spring in the thick block has twice the extension (or compression) of its partner in the thin block. So the spring in the thick block stores four times the energy of its partner spring in the thin block. Furthermore, the thick block has twice as many layers as does the thin black, so each spring in the thin block has two partners, with identical extension, in the thick block. So the thick block stores eight times the energy of the thin block (for the same deflection y).

Thus

$$\frac{k_{\text{thick}}}{k_{\text{thin}}} = 8. \qquad (9.23)$$

This factor of 8 results from multiplying the thickness by 2. In general, stiffness is proportional to the cube of the thickness:

$$k \propto h^3. \qquad (9.24)$$

Because the entire wood block acts like a spring, its oscillation frequency is $\omega = \sqrt{k/m}$. The mass ratio is caused by the thickness ratio:

$$\frac{m_{\text{thick}}}{m_{\text{thin}}} = 2. \qquad (9.25)$$

Because the stiffness ratio is 8, the frequency ratio is

$$\frac{\omega_{\text{thick}}}{\omega_{\text{thin}}} = \sqrt{\frac{8}{2}} = 2. \qquad (9.26)$$

very well explained

It took me a while, but I think I understand it. It would be nice to somehow demonstrate this using the above images.

perhaps you can use this space to also specify what 2s were multiplied since they're stated in the above and below paragraph but not summarized.

This sentence is misleading. I understood the paragraph above it, but this sentence threw me off for a second. The ratio of the thicknesses is 2, and you say to multiply by 2, which would lead me to a conclusion of 4, which is, of course, not 8.

i think you mean for a piece twice as thick, rather than "multiplying"

In what units is 'stiffness' measured?

Force per displacement (so, mass*length/time^2 divided by length => mass/time^2).

stiffness in this case is k, the "spring constant"

Would it be better to mention this fact before jumping into the ratio equating to 8 and then explaining later?

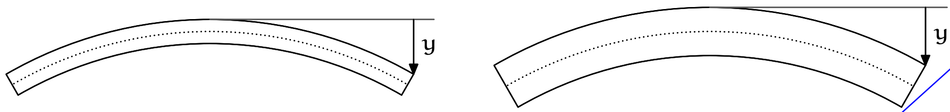
This answers where the 8 came from. The above paragraphs made the reader want to guess at how it came from before you arrive at the explanation more concisely. Maybe a reordering of the timing of when you present this would be good?

I think this is just a good thing to memorize. Does it only hold for wood?

it sounds like it can be more general ("in general"), though I have never heard this before

As long as you're going to memorize, just remember k b*h^3 (i.e. first power in beam width, third in beam height). This comes from the bending moment of inertia of a rectangular beam, which is I=b*h^3/12, and k YI (Y is young's modulus)

To find the stored energies, look at this picture of the blocks, with the dotted line showing the neutral line (the line without compression or extension):



The deflection hardly changes the lengths of the radial-direction bond springs. However, the tangential springs (along the long length of the block) get extended or compressed. Above the neutral line the springs are extended. Below the neutral line, the springs are compressed. The amount of extension is proportional to the distance from the neutral line.

Now study comparable bond springs in the thin and thick blocks. Each spring in the thin block corresponds to a spring in the thick block that is twice as far away from the neutral line. The spring in the thick block has twice the extension (or compression) of its partner in the thin block. So the spring in the thick block stores four times the energy of its partner spring in the thin block. Furthermore, the thick block has twice as many layers as does the thin black, so each spring in the thin block has two partners, with identical extension, in the thick block. So the thick block stores eight times the energy of the thin block (for the same deflection y).

Thus

$$\frac{k_{\text{thick}}}{k_{\text{thin}}} = 8. \tag{9.23}$$

This factor of 8 results from multiplying the thickness by 2. In general, stiffness is proportional to the cube of the thickness:

$$k \propto h^3. \tag{9.24}$$

Because the entire wood block acts like a spring, its oscillation frequency is $\omega = \sqrt{k/m}$. The mass ratio is caused by the thickness ratio:

$$\frac{m_{\text{thick}}}{m_{\text{thin}}} = 2. \tag{9.25}$$

Because the stiffness ratio is 8, the frequency ratio is

$$\frac{\omega_{\text{thick}}}{\omega_{\text{thin}}} = \sqrt{\frac{8}{2}} = 2. \tag{9.26}$$

And all this time, I'd always assumed k stiffness to be an intensive property. Goes to show you even the basest assumptions should be double-checked.

One example that I often think of to remind myself that the stiffness isn't intensive is that thin sheets of metal (or any other substance, for that matter) are much easier to transform than thick blocks. Therefore, the stiffness must increase with thickness.

Now I remember, the *elastic modulus* is the intrinsic property! THAT'S how you can derive the stiffness with other knowns. I'm really glad I remembered that, I think I would've gone crazy otherwise.

I can follow how the bonds between atoms act like springs, but how is the entire wood block like a spring now?

If you get two springs, and connect them, you still have a spring! Now, if you have this elaborate network of springs, at the end, you still get a spring out.

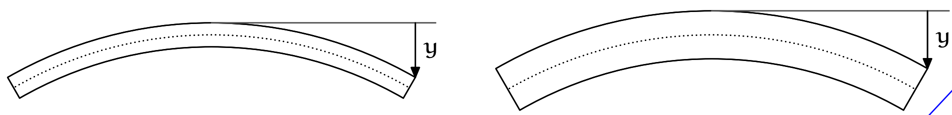
You know how complicated circuits with resistors have a resistance, it's kind of like that. All these elaborate springs in the end have some effective "k".

I can follow how the bonds between atoms act like springs, but how is the entire wood block like a spring now?

The entire wood block is made up of these springs therefore the entire thing acts like a spring. Imagine a set of springs all hooked up to one another.

Yeah, if you remember in mechanics, they dealt with problems where two or more springs are connected together... then we solved to find that it acts like a "new" spring with a "new" spring constant that is expressed as a function of the individual spring constants. I guess springs preserve their spring-like nature from a microscopic level to a macroscopic level, sort of like fractals.

To find the stored energies, look at this picture of the blocks, with the dotted line showing the neutral line (the line without compression or extension):



The deflection hardly changes the lengths of the radial-direction bond springs. However, the tangential springs (along the long length of the block) get extended or compressed. Above the neutral line the springs are extended. Below the neutral line, the springs are compressed. The amount of extension is proportional to the distance from the neutral line.

Now study comparable bond springs in the thin and thick blocks. Each spring in the thin block corresponds to a spring in the thick block that is twice as far away from the neutral line. The spring in the thick block has twice the extension (or compression) of its partner in the thin block. So the spring in the thick block stores four times the energy of its partner spring in the thin block. Furthermore, the thick block has twice as many layers as does the thin black, so each spring in the thin block has two partners, with identical extension, in the thick block. So the thick block stores eight times the energy of the thin block (for the same deflection y).

Thus

$$\frac{k_{\text{thick}}}{k_{\text{thin}}} = 8. \tag{9.23}$$

This factor of 8 results from multiplying the thickness by 2. In general, stiffness is proportional to the cube of the thickness:

$$k \propto h^3. \tag{9.24}$$

Because the entire wood block acts like a spring, its oscillation frequency is $\omega = \sqrt{k/m}$. The mass ratio is caused by the thickness ratio:

$$\frac{m_{\text{thick}}}{m_{\text{thin}}} = 2. \tag{9.25}$$

Because the stiffness ratio is 8, the frequency ratio is

$$\frac{\omega_{\text{thick}}}{\omega_{\text{thin}}} = \sqrt{\frac{8}{2}} = 2. \tag{9.26}$$

This is a good formula to remember

I agree, it pops up all over the place in mechanical physics because it works for all different "effective stiffnesses" and "effective masses."

Are we expected to know this off the top of our heads? I'm course 6, and I certainly don't know this formula.

Actually, you can derive it pretty quickly by dimensional analysis. Omega has units of 1/time, and the only other given quantities are k (units of force/length = mass/time^2) and m (units of mass), so to get units of 1/time, we must take the square root of k/m. It also makes intuitive sense because increasing k (the stiffness) will make the block return to its original shape faster (higher frequency), while increasing m will make the block harder to accelerate (lower frequency).

Yeah I didn't know this one either, it seemed like a very convenient equation without a reason. Very good explanation of unit analysis for this though.

yeah it's very handy to know the natural frequency of materials, especially if you're designing something that will move. you want to make sure that the part's natural frequency is a lot higher than the vibrations in the piece so it doesn't cause resonance.

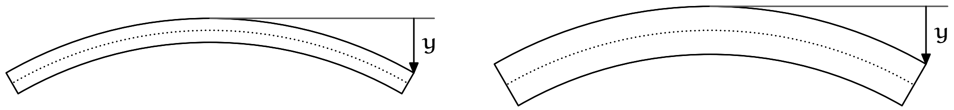
You also get exactly the same issues designing certain kinds of circuits – you want your switching frequency to be far above or below the resonant frequency of the circuit (unless resonance is your goal, of course). It's pretty cool to see the ways that we're all using the same basic concepts...

I think its incredible that we can get to this point just by reasoning, you just have to think about things the right way

Definitely...this example is awesome simply because the conclusion is so concrete and correct, despite the beginning of the section clearly outlining the difficulty in making the guess whether or no the ratio will be greater or less than 1.

I think I'll use this example as the first physical example of springs. Maybe I'll use the cosine integral as a short introduction to the parabolic approximation in general, then explain how the interatomic bond potentials have the same property – which means they are springs. Then ask the wood-blocks question and analyze it. (The planets should probably come later – or never.)

To find the stored energies, look at this picture of the blocks, with the dotted line showing the neutral line (the line without compression or extension):



The deflection hardly changes the lengths of the radial-direction bond springs. However, the tangential springs (along the long length of the block) get extended or compressed. Above the neutral line the springs are extended. Below the neutral line, the springs are compressed. The amount of extension is proportional to the distance from the neutral line.

Now study comparable bond springs in the thin and thick blocks. Each spring in the thin block corresponds to a spring in the thick block that is twice as far away from the neutral line. The spring in the thick block has twice the extension (or compression) of its partner in the thin block. So the spring in the thick block stores four times the energy of its partner spring in the thin block. Furthermore, the thick block has twice as many layers as does the thin black, so each spring in the thin block has two partners, with identical extension, in the thick block. So the thick block stores eight times the energy of the thin block (for the same deflection y).

Thus

$$\frac{k_{\text{thick}}}{k_{\text{thin}}} = 8. \tag{9.23}$$

This factor of 8 results from multiplying the thickness by 2. In general, stiffness is proportional to the cube of the thickness:

$$k \propto h^3. \tag{9.24}$$

Because the entire wood block acts like a spring, its oscillation frequency is $\omega = \sqrt{k/m}$. The mass ratio is caused by the thickness ratio:

$$\frac{m_{\text{thick}}}{m_{\text{thin}}} = 2. \tag{9.25}$$

Because the stiffness ratio is 8, the frequency ratio is

$$\frac{\omega_{\text{thick}}}{\omega_{\text{thin}}} = \sqrt{\frac{8}{2}} = 2. \tag{9.26}$$

This reasoning makes a lot of sense to me.

This actually took me a couple minutes to figure out. I somehow overlooked the w=(k/m)^-.5 in the previous line. Perhaps that would be better placed right before this ratio of w's.

Yeah this little math reasoning right here is obvious to me, but I never would have come up with the rest..and its pretty crazy that frequency turns out to be directly proportional to thickness

so if it were 8 times as thick then the frequency ratio would be 8? pretty neat. Does this scale for any thickness?

There must also be some point where the object simply doesn't produce any audible sound. The volume of the sound must decrease with thickness, or the object simply becomes so stiff that hitting it only locally deforms the object instead of making the whole thing oscillate, it would be interesting to see where this point lies, and see how the frequency really does/doesn't scale with frequency.

That makes sense since volume is proportional to how much the object perturbs. So a less stiff plank would move more air around making it louder.

In general, $m \propto h$ so

$$\frac{\omega_{\text{thick}}}{\omega_{\text{thin}}} = \sqrt{\frac{h^3}{h}} = h. \tag{9.27}$$

Frequency is proportional to thickness!

Comments on page 4

I think you should give a overall summary of this relevance. Connect it back to the beginning of the chapter, and site why this is important.

I really liked this analysis- Thanks!

so k is also prop. to h?

k is proportional to h^3

This was a cool analysis, but I'm wondering if we didn't use the fact that we knew what happened to explain why it happened. To me, it's cooler to go from basic principles to having a prediction. I think we did this in this section–but it might be more impactful to have the analysis first, then the experiment to confirm our analysis.

although, it's useful to note that science tends to work in the opposite way: someone notices something and tries to explain the phenomenon with the analysis.

Cool!

This lecture seems relatively simple, but I still am not sure if I completely understand it.

is this assuming the other dimensions are effectively infinitely larger?

or that the thickness is very thin.

Yes, it does, or at least within a large enough range.

Okay. Thanks for the clarification. I originally missed this distinction.

Are there any types of materials for which this doesn't apply?

Wouldn't this still apply, regardless of the thickness? You just might need a larger force to excite the block to an audible frequency of oscillation...

I would never have thought that. I was sure it would have been the opposite.

Yea, I assumed it would be proportional to thickness but in the sense that the thicker wood would change the wavelength, not in the way of affecting the vibration of the wood

yeah this is a really cool result, that I would not have expected!!

In general, $m \propto h$ so

$$\frac{\omega_{\text{thick}}}{\omega_{\text{thin}}} = \sqrt{\frac{h^3}{h}} = h. \tag{9.27}$$

Frequency is proportional to thickness!

How did this compare to the results from your experiment?

It would be nice to mention this (some numbers/data would do). I remember in class you said that the frequency of the thick block was nearly an octave higher than the frequency of the thin block.

I agree. In lecture you mentioned it was actually a Major 6th interval. Is the discrepancy from geometry or material error, edge effects, or something else (like something more subtle that's affecting the frequency)?

So how does this result relate to the xylophone problem from the pretest (where we are adjusting length not thickness)?

This finding is a different relationship. From what I remember, in the xylophone example, shorter bars corresponded to lower pitches and longer bars to higher pitches.

I thought is was the same relationship. Both examples deal with 2 constant dimensions and 1 dimension that varies. The only difference between the xylophone and the block-example is which dimension varies between multiple planks.

Ah, that's the subject of lecture today (I have a xylophone)!

I'm sad I missed that! And I'm pretty sure that the longer bars are lower...

Might be nice to tie this conclusion into the first paragraph or two...

I agree, the most surprising part to me is that it is linearly proportional to the thickness. A little recap would have brought things together well.

Agreed, just a short recap would be great. It's not absolutely necessary, but it's always nice just to get a few sentences tying up the issue or problem that was presented a few pages ago. Even just "the thicker block has a higher frequency" would be great.

Wow, this was pretty interesting that this could all be explained using 8.01 concepts.

Interesting example! I liked that it was less mathy in the reasoning and relied a lot on just thinking about the picture also.

Is this the end of the textbook?