That brings us, then to problem 5 B.8.

There's a bit of a hassle: we have two sleds. You are sitting in one sled, and your mass plus the sled is 90 kilograms, and you have a block here which is 10 kilograms. It's on a frictionless surface-- it's on ice--- and here is your friend. Your friend, plus her sled or his sled, has a mass m 2 of 70 kilograms. You slide this block to your friends, your friend catches it, your friend slides it back to you, and you catch it. The question now is, when this is all over, this exchange of this block-- when this is all over, the question is, what is the velocity of each one of the two sleds?

You're being told that every time that you move the block away from you-- that happens twice-- you first move it away from you, and then, of course, your friend moves it away from her or from him. The relative velocity between the sled and the block is two meters per second.

This comes into various steps. Let's first take step one. We have this situation, and a little later when this block has moved, we have here the mass of 90, which moves backwards. I will give that a notation 90-- you may not like that. Here I have the block, which goes in this direction-- v 10-- forget this one. We know that's the relative velocity between the two is two meters per second, and between the two, not relative to the ice, this relative to the sled is two.

I will introduce unit vector in x direction, and I called that x roof, and I know that Professor Guth is not doing that too often. What this means, then, is that v 10 minus v 90 equals plus 2x-- that is the information that the relative velocity equals 2.

Now I'm going to do something that you may not like. I know that the velocity of v 90 is in this direction-- that's a given that will not change. Therefore, I'm going to leave the bar off, and already substitute in here a minus sign. It's so that the number that I will find later is the speed for v 90, but the direction is nonnegotiable-- it must be in this direction-- and v 10 I know is in this direction, so I will give that a plus sign. I know whatever sign I find later for v 10, it will be in this direction.

That, then, becomes v 10 plus v 90, because minus times minus is plus equals plus 2, and this is my equation one. I got rid of my vectorial bars, but I keep this in mind.

Now, the momentum here is 0, so the momentum here must also be 0. If I write down the conservation of momentum, I have 0 momentum, and that equals 90 times v 90 plus 10 times v 10. This is the momentum I have before, and this is the momentum I have after-- it's in vector notation. I play the same game, the game that I'm going to play with the minus signs, and so I can change this to minus 90 times v 90-- no longer bars-- plus 10 times v 10 equals 0, and I call this my equation two.

I have now two equations with two unknowns, and what do I find? I find when I solve it, that v 10 equals 1.8-- it better be positive, because if it doesn't come out positive, I would have made a mistake, because all the numbers most be positive. The numbers that I've put in are speeds-- and v 90 is also positive plus 0.2. We already assigned it to go in this direction. You see that the difference is 2 meters per second, this, 1.8, this, 0.2-- the difference is two meters per second. It better be two meters per second, because I put that in my recipe.

So now I have a situation that I have to go to phase two. I have now here this object-- 10-- moving towards your friend with a velocity of 1.8. Here is your friend, eagerly waiting-- mass 70, and it has no speed. A little later, when your friend has caught this block, here is the 10, and here is the 70. Both of you will go in this direction, and let's call it just v 2.

I have problems with assigning all these nomenclatures-- I hope you forgive me for that. I simply call this v 2 now-- this is a velocity in this direction of the block, and your friend after the catch is made. No one is shoving anything now, so all I have to take into account in this situation, and nothing else, is the conservation of momentum.

Before the hit, the moment I have is plus 10 times 1.8, which is 18. The momentum is only in here, because this stands still-- afterwards, I have 80 times v 2, and so it follows immediately that v 2 equals 18 divided by 80, which is 0.225 meters per second in this direction. I know now after the impact that the two go together with this speed.

Now we come to phase number three. What is happening now is that this block with the 70 is moving with the 0.225. A little later, 10 will be moving in this direction-- let me call that again v 10-- and the sled with your friend is moving in this direction, and let's cool that v 70. You have to apply now-- which is not so difficult-- only the conservation of momentum on this system, and I'd like you to do that.

Then, of course, you have to go to phase four, because here you are with your 90, and you're going back, I believe, it was 0.2 meters per second. Now when this one hits you, then you'll have to again use the conservation of momentum. I mentioned here that all you have to do is use the conservation of momentum: that's not true, because you also have to take into account that this velocity and this velocity have a difference off 2-- so I misled you.

To go from here to here, you must take into account conservation of momentum plus the fact that the difference in velocity is 2. When this object in phase four is this object, then all you have to take into account is the conservation of momentum, because no one is sliding any object anymore. It's a lot of work, and I leave you with that. I want you to appreciate, though, that none of these collisions-- if you think of them as collisions, because when you slide something away from you, there is some kind of a collision, and when you absorb it, that is some kind of a collision-- are elastic. Kinetic energy is not considered.

You can easily see it. If you catch the block, then the two velocities after you catch it are the same: you're stuck. It's like the marble stuck to the putty-- there's always an inelastic collision. Where does the energy go? Kinetic energy is destroyed to some degree-- [UNINTELLIGIBLE] goes into it. Maybe it goes a little bit into sounds, and maybe it goes into breaking the block in pieces-- it has to go somewhere, but not in kinetic energy.