The document serves as supplementary material for the manuscript titled, "Beyond Epistemological Deficits: Dynamic explanations of engineering students' difficulties with mathematical sense-making," published in International Journal of Science Education, 2011.

Background:

"Jim" (pseudonym) is one of seven engineering majors we clinically interviewed in fall 2008, for the NSF-funded project *Improving students' mathematical sense-making in engineering: research and development*. All were taking the freshman first-semester calculus-based introductory physics course at a large mid-Atlantic State university. They all responded to a class wide email asking volunteers to be interviewed for $10. The interviewer was not involved in teaching the course.

Interview Protocol

To explore what facilitates or hinders engineering students' mathematical sense-making in introductory physics courses, the interviews focused on how students explain (to themselves and others) and use physics equations when solving physics problems. Interviews occurred in the Physics building and addressed equations and concepts from their course. In this way, we hoped that the obstacles to mathematical sense-making observed in the interview would relate to the obstacles cued by their course work, making our findings instructionally relevant.

Jim's interview occurred on {fill in date} and lasted {fill in number of minutes}. The accompanying document lists the complete interview protocol; but the conversational flow in particular moments suggested on-the-fly modifications to these prompts, or construction of new prompts, to probe the student's thinking more deeply. In such moments, we prioritized pursuing the student's thoughts over strictly adhering to the interview protocol. Of course, when analyzing our interview of Jim, the degree of standardization across different interviews becomes irrelevant.

The interview starts by asking students to explain an equation they are familiar with: $v = v_0 + at$, referring to velocity, acceleration and time. We tried to cue different pockets of students' knowledge with prompts such as, "How would you explain that equation to a friend from your English class?" or, "How would you explain that equation on a physics exam?" Subjects then solved a problem using that equation. We followed up by asking the subjects to make sense of an equation that is similar in structure to $v = v_0 + at$ but new to the students at the time of the interview: the hydrostatic pressure equation, $p = p_{at\ top} + rgh$, where p is the pressure under water in a lake or ocean, $p_{at\ top}$ is the pressure at the top, r is the density of water, g is the acceleration due to gravity and h is the depth below the water's surface. We then posed a problem that could straightforwardly be solved using that equation.

Interview protocol

Velocity Equation (V)

(V1) Here's an equation you've probably seen in physics class: $v = v_0 + at$. How would you explain this equation to a friend from class?
(V2) How would you explain this on an exam? .... to a 12-year old?

The Two Balls Problem (B)

(B1) Suppose you are standing with two tennis balls in the balcony of a tall building. You throw one ball down with an initial speed of 2 m/s; You just let go of the other ball, i.e., just let it fall. I would like you to think aloud while figuring out what is the *difference in the speed of the two balls* after 5 seconds – is it less than, more than, or equal to 2 m/s? (Acceleration due to gravity is $10 m/s^2$)
(B2) Could you have answered this without doing the calculations?

Hydrostatic Pressure Equation (P)

(P1) Here's an equation you perhaps haven't yet learned. It's a formula for the pressure at a given depth under the surface of a lake, ocean, or whatever: $p = p_{\text{at top}} + \rho_{\text{water}} gh$, where $p_{\text{at top}}$ is the pressure at the surface of the water, ρ_{water} is the density of water, and h is the distance below the surface. How would you explain that equation to yourself?
(P2) Is the pressure at h=5 meters under water greater than, less than or equal to the pressure at h=7 meters under water?
(P3) Consider a lake on the surface of Mars that has weaker gravity compared to earth. What that means is that "g" for Mars is lower than "g" for earth which is $10 m/s^2$. Is the pressure at a depth in the earth-lake greater than, less than, or equal to the pressure at the same depth for the mars-lake?

Newton's Law problem: Modified Atwood's machine (NL)

(NL1) Here's a problem you may have encountered in physics. *(Frictionless everything.)*
(NL2) Solve for the acceleration of the 1 kg block. (*I would like you to think aloud as you are working on this. We're not interested in the answer you get but in how you think about it.*)

Questions probing epistemology of equations in the physics context (E)

(E1) How do you know when you really understand an equation?
(E2) What's hard about learning or using the math in this physics course?
(E3) Suppose you had photographic memory for equations. Would that improve your performance? Why? *Follow-ups would try to tease apart whether the advantage is course specific or a more general failure of what it means to know math in a physics context.*
(E4) Suppose a student is taking the course for fun, and not getting graded, with the goal of understanding physics more deeply. He's/She's not interested in learning to solve the quantitative problems, but he's willing to study outside of class to learn the concepts better. What role if any should equations play in his studying?
(E5) Suppose you were given a list of equations on the exam – would that help you?

Transcript

Time Stamp format [hour hour:minute minute :second second:frame frame]

[00:00:06.21] Bill: Do you know about the study?
Jim: Not really
Bill: We are looking at how students think about math in the context of physics courses. That's what the study is about.
[00:00:29.04] Bill: This is the consent form. Explains the consent form.
[00:00:53.22] Jim signs the consent form.
[00:01:19.28] Bill: The other thing I wanted to tell you before we start is how you think about the problem, not whether you can get to an answer or not; just how you think about it. So keep talking, you know, tell us about your thought process. That's what is more important.
[00:01:46.16] Jim reads the velocity equation
[00:01:50.10] Bill: Suppose you had a friend from English class. How would you explain that to him.
[00:01:59.06] Jim: Velocity = initial velocity plus acceleration times time and it comes from derivative of position or the integral of acceleration. Because if you take the integral of this you would get position. I know the position equation of the top of my head. I could write that down and derive that to get this again.
[00:02:40.21] Jim: take the derivative of this. okay. this is constant. Do the simple .. you get “at”. which is . “dx dt”. Or you could use acceleration.
[00:03:26.09] Bill: you said, you could use the acceleration. Could you tell me more?
[00:03:29.22] Jim: You find the acceleration. Integrate the acceleration to find this.
[00:03:38.07] Bill: could you do that?
Jim: okay. a ... gt.... a equal ... (*works on that derivation)*
[00:05:14.00] Bill: you are essentially thinking that you integrate the [acceleration to get velocity] acceleration. you get the velocity. okay. so suppose the acceleration. so. so. where are you getting snagged here.
[00:05:26.17] Jim: I just can't do the integral of v_f over t.
Bill: Suppose I told you that the acceleration is constant.
[00:05:35.20] Jim: Acceleration is constant
Bill: Yeah, it is the same acceleration.
Jim: OK
Bill: Can you integrate that?
[00:05:49.24] Jim: I guess...you can integrate that because the velocity is still changing. It's increasing the...If you have constant velocity, then acceleration is zero.
[00:06:12.12] Bill: Here's another situation. Suppose there is a 12 year old kid. Who knows some amount of math but does not know physics. If you were to explain this to a 12yr old kid how would you go about doing that?

[00:06:27.26] Jim: I would tell him that. I will probably use the graph. like I would graph the position. and tell him that a tangent line is the velocity. so I will show him like this is a graph like this, this line is the velocity, this line here is the velocity. and I will tell him that you have not taken the class yet but we do have the ability to find this tangent line at any position with the derivative and that's why we take the derivate with respect to position to find the velocity. that's what I would tell him. so he should just be patient. he would learn in a few years.
[00:07:11.19] Bill: okay
[00:07:13.07] Jim: yeah
[00:07:16.03] Bill: so have a look at this problem here. um. it says that you are standing on the fourth floor and you are throwing the ball down with an initial speed of 2 m/s and you are letting go of another ball. okay. so, its asking you that after 5 seconds, what would be the difference in speeds of the two balls.
[00:07:41.28] Jim: difference in speeds.
[00:07:43.25] Bill: of the two balls. will it be less than, more than, or equal to the 2 m/s?
[00:07:50.10] Jim: uh.
[00:08:08.02]/just working; mumbling; not clear speech/
[00:08:22.00] Jim: so the other one has no initial velocity. you just let it fall.
[00:08:24.29] Bill: you just let it fall.
[00:08:30.22] Jim works on the problem more
[00:08:40.00] Bill: you can use "10" if you wanted for acceleration due to gravity. might be easier
[00:08:47.19] Jim keeps working on the problem.
[00:09:00.12] Bill: were you thinking about this one?
[00:09:04.06] Jim: I am trying to figure out what the acceleration is
[00:09:06.18] Bill: OK
[00:09:08.11] Jim: if you throw it down
[00:09:15.02] Jim is thinking quietly
[00:09:40.14] Jim: this is
[00:09:51.22] Bill: so you expect the acceleration to be ... were you thinking like
[00:09:54.28] Jim: I think its going to be 9.8 but since its coming with a higher v0, and this one the v0 is zero; so this would be, the v_f would be 52 m/s after 5 seconds; so they are not equal to each other but its equal to 2 m/s...what is it asking for?
[00:10:25.04] Bill: oh its asking for when we started off the initial you threw the ball down at 2 m/s, the other one you let go, and so the initial difference in speeds was 2 m/s and so after 5 seconds what happens to this difference of speed? yeah.
[00:10:45.03] Jim: I would say its equal to (stretches out the to) but I think. highly doubt. it might be more, but I think its equal to.
[00:10:51.28] Bill: why do you think that

[00:10:55.05] Jim: because in free fall. its gravity; its 9.8. and this one has no initial v-; so its just 9.8 times 5. this one has a vo. so its at plus the v0. 52 and 50 - the difference is 2 m/s
[00:11:17.04] Bill: tell me umm, you were initially hesitating about this as the acceleration what were you thinking there?
[00:11:28.12] Jim: cause I mean if you throw it down, the acceleration is faster as opposed to just letting it go; then there is nothing extra acting on it and so how can it keep in accelerating. I wasn't sure initially.
[00:11:55.09] Bill: could someone have figured this problem out without actually working out the numbers?
[00:11:59.26] Jim: umm, someone who really knows physics probably would.
[00:12:10.29] Jim: i mean I did not have to write this. I could have done this in my head. but "a" is 10 "t" is 5. I can do 10x5 + 2 without writing it out, but you have to do some process.
[00:12:24.11] Bill: but without explicitly plugging the numbers and doing the calculations. Be it in your head or on paper could someone have just reasoned through the problem and figured out the solution. and figured out, you know, the same thing.
[00:12:44.15] Jim: they could have been really close, but I am not sure if they could have got an exact answer.
[00:12:48.26] Bill: okay
[00:12:50.00] Jim: and
[00:12:56.08] Bill: so um. here is another equation. have you seen this one?
[00:13:03.28] Jim nods in negative.
[00:13:05.18] Bill: so this is just an equation about pressure. Pressure inside water. a lake or ocean or something like that right. it just gives you an expression for that in terms of the pressure on top and then the density of the water and acc due to gravity, g, and the depth of water from the surface h. so suppose you were trying to understand this equation, you were trying to make sense of it. how would you go about doing that.
[00:13:36.25] Jim: so from the question this g is gravity and this is height?
[00:13:45.08] Bill: g is gravity and h is the depth below the surface. he is the distance below the surface.
[00:13:59.19] Jim works on the problem quietly
[00:14:20.26] Jim: Can I ask you a question?
[00:14:20.26] Bill: Sure
[00:14:22.28] Jim: What's the units on pressure?
[00:14:24.28] Bill: Newton per meter squared
Jim: Newton per meter squared
[00:14:34.22] Jim: mass times acceleration [working on units]
...Jim is still working on the problem
[00:15:13.10] Bill: What were you ... um
Jim: I was just trying to figure out the units
...

[00:15:34.00] Jim: wait, these two are the same? [points to "p" and "rho"]
[00:15:37.01] Bill: no; that is the pressure on the top and that is the density of water. So yeah, they are different
[00:15:44.09] Jim: Okay.
...Jim looks at the equation; not speaking.
[00:16:04.11] Jim: I would say when I multiply these, what gets out has to give you the units of pressure or something similar because you can't add two things that aren't the same units
[00:16:16.16] Bill: Okay
[00:16:17.28] Jim: That's what I was trying to figure out.
... (Jim working silently.. mostly looking at the paper)
[00:16:56.20] Bill: So did you check on the units? they match?
[00:16:59.28] Jim: That's what I am trying to double check.
[00:17:05.21] Jim: (mumbling) so this is Netwons per meter squared ... (mumbling and then silent for a few moments)
[00:17:42.18] Jim: I don't think they match. I don't know why.
[00:17:49.26] Jim: oh! cubed.
[00:17:54.22] Jim: thats ...
[00:18:01.11] Jim: wait. you said this is meter squared.
...(Jim working on units)
[00:18:23.04] Jim: kilogram..
[00:18:46.08] Bill: Okay.
[00:18:53.24] Bill: Is that Newtons per meter squared?
[00:19:14.16] Jim: I mean kilogram ... squared...
[00:19:27.09] Jim: ah! it does match.
[00:19:30.01] Bill: are you happy?
[00:19:32.12] Jim: Yeah. /smiles looking at his work/
[00:19:39.10] /still looking at his work/
[00:19:38.03] Jim: What do they mean by how would you explain this equation to yourself? If I see this, I will first make sure that units match
[00:19:51.04] Bill: Okay
[00:19:57.22] Jim: What else do they mean by how would you explain this equation to yourself?
[00:19:57.03] Bill: Um, does this equation make sense to you?
[00:20:02.07] Jim: The units make sense, so it has to be heading somewhere [okay]
[00:20:13.01] um so suppose we asked you to explain the equation on an exam
[00:20:23.28] Jim: units of \works out the units\ plug it in
[00:20:46.13]okay
[00:20:54.01] Bill: Suppose we asked you to compare the pressure at h=5 and h=7?
[00:21:09.07]/jim looking at the problem on the page; writing out some values/
[00:22:14.17]can you tell me what you are thinking

[00:22:17.00] Jim: It's just the pressure units. what do you use for pressure, pascal.
Bill: So which one is more?
Jim: Which one is more ....
/looks back at the paper and reading or thinking/
[00:23:37.12] Bill: What are you thinking?
[00:23:38.12] Jim: Trying to think about how to plug in the numbers in both cases to see which is bigger
[00:23:42.27] Bill: which number are you thinking (worrying?) about?
[00:23:48.01] Jim: I am just like trying to formulate a problem. I have never seen a pressure problem before so have to think.
[00:24:01.23] Bill: If you need any quantities let me know
[00:24:03.10] Jim: Wait, does under water does it mean negative
Bill: So it is set up so that "h" is the distance below the water
Jim: okay, that means it is negative
[00:24:16.26] Bill: Umm,
Jim: depends on what your axes are?
Bill: In this equation, the way h is mentioned, it is defined as going down from the water surface
Jim: Then 5 is greater and 7 is smaller
Bill: Why do you say that?
[00:24:39.01] Jim: because if its going down then it is negative.
Bill: What is negative?
Jim: "h" is negative and then 7 is a smaller number and 5 is the bigger number
Bill: Because of the negative?
Jim: Yeah
[00:24:51.21] Bill: Suppose I told you that negative is actually built inside of h
Jim: So its absolute value?
[00:24:57.12] Bill: Yeah, suppose that's how it works
Bill: Like don’t take the negative
/pauses/
[00:25:12.18] Bill: Would that change your conclusion?
[00:25:17.17] Jim: I think it will. but
[okay]
Jim: It will. For then 7 is positive.
[00:25:32.05] Bill: Could you figure out, which one of those should be. Could you reason through which should it be
[00:25:39.13] Jim: Which it should be
Bill: Like should the 7 be more than 5 or the 5 be more than 7
[00:25:45.08] Jim: I think ... 7 is greater than 5. But if you put in a negative then negative 5 is bigger than negative 7.
[00:26:01.04] Bill: Suppose, there was a friend of yours in English. Does not really know physics and equations, kid of thing, Could they have answered this question?

[00:26:20.20] Jim: This question
Bill: Just the questions that you know, under water is the pressure greater than less than or equal to at a depth of 7 meters versus a depth of 5 meters
Could they have answered that without really knowing physics?
[00:26:38.19] Jim: not if they have experience being under water themselves
If they have that, then they can
[00:26:46.10] Bill: Okay, so what do you mean when you said, they have experience
[00:26:50.08] Jim: Like they have actually been under water and experienced the pressure. They might know a little bit about pressure under water
Jim: like they have gone snorkeling under water
Bill: What would they know
Jim: Like a rough estimate, the pressure was high when I was deeper, The pressure was low when I was higher to the surface. But actually working an equation, I don't think.
[00:27:25.10] Bill: Given that information, given that experience. could they have argued which pressure would be more 7m or 5 m. not from equations maybe but
[00:27:42.17] Jim: I mean they could have argued it but..
Bill: What would they have argued?
[00:27:46.04] Jim: They could have argued about their personal experience. One time I was like scuba diving and I was like 30 feet under the water and the pressure was felt like pressure was very high. Like I was just swimming and I was couple feet under water and pressure was not that high.
Bill: Then they woudl say that pressure at 7 m is greater then
Jim: greater than 5. What they are not seeing is factor of negative sign.
[00:28:20.03] Bill: So, do you think the math here is telling you something different
Jim: I think it is
Bill: okay.
[00:28:28.02] Bill: So suppose you have to answer this question on an exam, u which one would you pick. the experience one or ..
Jim: math
Bill: or math one?
Jim: I would pick the mathematics.
[00:28:39.09] Bill: Can you tell me why?
Jim: Umm, because .. math for an equation to be given to you, it has to be like theory, and it has to be fact bearing. Fact applies for everything. Its like a law. it applies for every single situation you can be in. But like, experience sometimes, your perception is just different or you don't have the knowledge of that course or anything. So I would go with the people who have like done the law and it is has worked time after time after time.
[00:29:19.08] Bill: Um, so, do you think this equation relates to that experience. That pressure is more at a greater depth. Does that equation?
Jim: this one

Bill: yeah, does it relate to that experience?
[00:29:35.19] Jim: probably somehow but not directly [Ca you tell me] like I think there is underlying in some way that just completely links the two together, but its not obvious what that relation is.
[00:29:51.20] Bill: okay. Are you still worrying about the positive and negative. So, suppose I told you that h is positive.
[00:29:59.10] Jim: Always positive.
Bill: yes. So I am taking the positive distance from the surface. But its considered positive. Would that help you?
jim: I mean. [okay] this makes 7 greater than 5.
[00:30:16.15] Bill: Does that bother you?
[00:30:22.11] Jim: Its just.. what I can't is that you are going "down" (emphasis) so 7 can't be greater than 5 and negative. that why I keep thinking. .. meaning if you do say its positive, ... I guess it doesn't bother me. mutters something.
Bill: Hmm
Jim: I said, 7 is greater than 5 in positive land. So ... if you say its positive then.
[00:30:55.29] Bill: So, do you think your friend would be happier than ..
Jim: they probably would be. Because they would be right. But ..
[00:31:07.02] Jim: They probably would be, yeah. because then their theory makes sense or their hypothesis makes sense.
[00:31:17.14] Bill: you are thinking that h could be negative as you are going down. [yeah]. okay. What would that predict, or , for that the physical situation. Could you relate your math, what the math is telling you to the physical world? what would it mean for.... so suppose h was negative, what would it mean for pressure as you go down
[00:31:46.09] Jim: that its higher, as you go down. because. ... (looks at the papers) ... like, /writes on paper/ oh! it would mean when you are higher the pressure is higher.
Bill: When you are higher? like more to the surface.
Jim: yeah, when you are closer to the surface, the pressure is higher. When you are lower the pressure is smaller. Okay.
[00:32:38.00] Bill: Suppose there is a 12 yr old who wants to understand this equation, what would you tell
[00:32:43.23] Jim: laughs. what would I tell? looks up- thinking- I don't know. I am not really sure of this, I don't know if I can explain this to anyone else. /quiet/ Well, I will tell him that some things aren't always how you perceive it. Like you might think something, but actually its the opposite or something like that. Like what it seems like in this case, and ...
[00:33:41.18] Bill: So tell me what you mean by
Jim: things aren't
Bill yeah
Jim: this negative. If its negative for example, it would really help you, it would not help you, You might mean...gravity.. just like the way...you don't think of

things acting negative. You think of things being positive. As positive, it would give you a higher number instead of a negative number,
[00:34:33.25] Bill: "h" you said is negative - because going down [Jim: that’s what I think] What do you think about g in this equation.
[00:34:41.17] Jim: Ohhh
Bill: Should that be minus 10 or plus 10
Jim: minus 10 also.
Bill: minus 10. Okay
[00:34:47.22] Jim: so that gives you a positive thing. The negative actually doesn’t matter. Ooh. I see. So the higher you go, the lower you go under water, the more your pressure is. The negative and negative just cancel off [okay]. So we have..So, the more under water you are, the higher your pressure is going to be then, I think now. I forgot to factor in "g" That’s what I think.
[00:35:43.25] Bill: Is that more comfortable or less comfortable.
Jim: That's more comfortable. Because it actually makes more sense to me now. And your experience, actually does work. For your experience under water, you felt more pressure as opposed to being closer to the surface. If you take into consideration the both negatives then...just add up.
[00:36:14.12] Bill: Think of a different problem now. Comparing an earth lake and mars lake. We are comparing pressures at the same depth for both lakes. WE know that gravity is much lower on mars compared to earth. [Jim: lower]. yes.
///reads the problem///
[00:36:42.02] Bill: How would you compare the two pressures.
Jim: gravity is lower on Mars, then there is less pressure on same depth at Mars.
Bill: Okay. So how did you figure that out.
[00:36:59.04] Jim: if "g" is 5 adn depth is 7. If "g" on earth is 10, h is "7". This is greater than that. So I figured it out.
Bill: So you just take the number less than 10 and ... okay
[00:37:29.23] Bill: What about p-top. did you worry about that.
Jim: p-top. Pressure at surface.
Bill: because you are comparing these two terms.
[00:37:57.16] Bill: Do you think about that.
Jim: no . not at first
Bill: so why were you.. did you assume that these were the same or..
Jim: yeah, I assumed they were the same.
Bill: okay.
Jim: I guess they are.
///quiet////
[00:38:50.08] Jim: Are their pressures the same or are they like independent of each other. pressure on surface or earth and surface of mars.
Bill: they are not related. but if you had to compare. could you figure that out.
[00:39:22.28] Bill: Tell me, when do you feel that you. like how do you know when you really understand an equation

[00:39:29.20] Jim: When you can. Equation for me is not like when you plug in numbers. you have to like decipher it just through the variables first. you have to work through the units and like decipher it. So if I can do that for pretty much any problem, then that's how I know I understand it.
[00:39:56.06] Bill: What do you mean by decipher it?
jim: Like, I will give you an example, our teacher gave on our test. Gave us like n=vt/a and told us to find what n was in terms of like, v being the velocity, a being acc, and t being time. so if I can decipher, wasn't exactly that but something like that. So if I can decipher. cancel out what has to be cancelled. I can figure out the units for what n is - and once I understand it, then I am not just looking at numbers, which may cancel out each other sometimes. If I can work that out, I would say I understand, in terms of the units as opposed to plug in the numbers. Then I would say I understand an equation.
[00:40:51.04] Bill: And umm, is that something that you learned in this physics course or
Jim: I mean, my teacher in high school talked about it, but like, that Dr. Wellstood put a hammer on it ... he does not put in the numbers till the last step. So that is them more obvious.
[00:41:22.15] Bill: What do you find difficult about using umm, math in this course.
[00:41:30.17] Jim: umm physics.... umm,,.. ... ... ///stretches// sometimes the algebra is like ridiculous. For example, like , for the equation x = x0 + vt + quadratic. Its just like, so difficult to do the quadratic for that. So, sometimes, the algebra is just difficult.
[00:42:36.12] Jim: its mostly the algebra. Because sometimes you don't see that as easy algebra. Cos I don't see it that way.
Bill: the solving of the problems
Jim: yeah
Bill: okay
[00:42:50.03] Bill: Is that what you find difficult about similar equations in the math course.
Jim: yeah. Math 141 now, sometimes you see something and I just.... Like when a teacher points it out, it becomes obvious to me though but sometimes you are supposed to treat something as a variable. sometimes you just factor it out. Sometimes I don't see it. and I would try to treat it as a number and that just makes my life hell.
Or like, sometimes you see like a number, ... treat it like a function .... something that does happen in my math class.
[00:43:35.19] Bill: okay
um. have a look at another problem.
[00:43:50.09] Bill: 2 kg block. modified Atwood problem. how would you figure out the acceleration for the 1kg block. not asking you to get a solution. how would you think about it.
[00:44:44.13] Jim: ///drawing force///

[00:45:06.18]
[00:45:34.07] Jim: Jim: I changed it to mass 1 and mass 2.
[00:46:09.09]//working//
[00:46:17.19] Bill: Could you tell me what your problem is
Jim: for this one, the tension. This one, this one. is going to determine how fast the block is going .. are these tensions the same thing. they are equal to each other?
[00:46:42.19] Bill: What are you thinking about that. Do you think they are the same?
[00:46:47.21] Jim: I think they are the same
Bill: Okay. Go ahead with that.
[00:48:17.01]//working//
[00:48:58.09]//working//
[00:49:14.17] Jim: this acceleration. half way.
[00:49:24.04] Bill: So consider somebody who does not know physics. All I tell them is that a block that is freely falling, that acceleration is 9.8. With that information could they have figured out if the acceleration is greater than, less than, or equal to 9.8 for this block
[00:49:55.09] Jim: I mean, I hope they would be able to figure out, because it is attached to something. //grasping gesture// Something is holding it back. //gestures puling something back with a rope// as opposed to letting it freely fall //gestures the free fall//
Bill: Okay. So the acceleration would be
Jim: Less
[00:50:28.04] Bill: And .um. do you know if your answer says that
Jim: I don't know. I think it says more than. because like I have those plus here. if it was negative it is less than 9.8. but because of the plus it is more than 9.8
Bill: What about the acceleration of the two blocks. Are they the same or?
[00:51:26.06] Jim: Are they the same? I think they are related by the tension. But I don't think they are the same. [Okay.]
[00:51:48.16] Bill: Suppose you had a photographic memory for equations. How would that help in your performance or would it.?
Jim: No; if your teacher has done a similar problem like this and you have a photographic memory and you remember the exact equation he had then you just plug into the...
Bill: So will it improve your performance on the course?
Jim: I mean it will, but you may not know the actual material. Might get good grades but...unless its there for everything, it might not really make you know the stuff.
Bill: So, what do you mean when you say, know the stuff
Jim: Well, it depends on how long your photographic memory is, IF it is just for the exam, you would get a good grade, but you would not know the actual stuff after. But if it is there for all eternity, then you will be fine. For you can always work back and find out...

[00:53:12.07] Bill: Think about another friend. Friend of yours is in the same course but //Diane prompt//
[00:53:45.02] Jim: Equations are very important. They need the equations for solving problems. They also need to know the equations to find out what is happening here. Like the force is acting the y-directions and x-directions, So I would say that equations are very important not just for good grades but for understanding the material.
[00:54:12.14] Bill: Do equations relate to phyisics, physical phenomenon. What role do equations play in physics.
Jim: They play an important role. What do you mean? I don't quite understand
Jim: I mean, they make things step by step. Do this equation first then that equation. Outlines the problem for you.

[00:55:32.02] Receipt.
[00:57:02.01] //Asks about the modified Atwood's machine//
Bill: suppose you were holding the two blocks would they move together
Jim:///gestures//they would move together, but their acceleration would not be the same///thinks for 2 seconds//their acceleration would be the same.//gestures on the table the Atwoods setup//acc. would be the same
//Bill works out the problem//