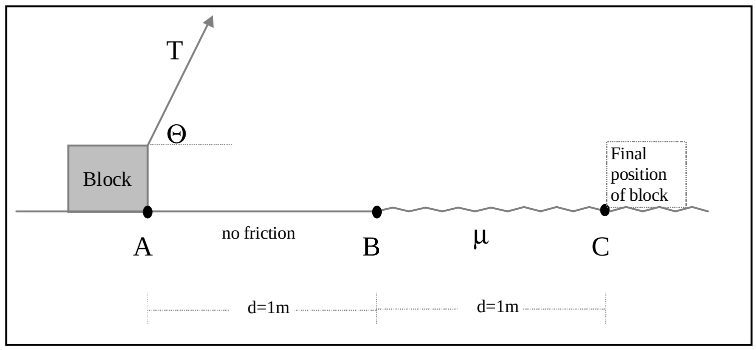
Appendix D: Full Interview Transcripts of the Interviews Used in the Dissertation: Undergraduate

Picture shown in problem from Figure 5 - 9.



"PINK" (3/24/97)

(reads question)

a) Draw a free-body diagram for the block when it's between B and C.

P: … So that is the block and there is the force of gravity — friction is going this way — tension is going like that and that's it — this is theta — this is going to be T cosine theta and this is T sine theta — and there is a normal force.

b) Is the magnitude of the net force acting on the block from A to B greater than, less than, or equal to the magnitude of the net force acting on the block from B to C? Explain your reasoning.

P: Well from A to B there is no friction so the magnitude of the force acting on the block is going to be greater because the free body diagram is going to be like that … [points to free-body diagram for block] *between A to B — where there is going to be no friction — this is friction. … The net force between A and B is going to be greater than B and C …Just because there is no friction so you are not going to have to subtract that from (IA) —*

c) Calculate the coefficient of kinetic friction between the surface and the block between B and C if $\Theta=60^o$, $m_{block}=1.5kg$, and T=5N.

P: So we know that friction is μ_k times the normal force — we know that the normal force is going to be the same as the weight, which is mg — because —

by NIII — … each force has an equal and opposite reaction — oh actually it is by the second law — F equals ma and there is no acceleration down so the sum of the forces is zero. … I am talking about the y direction.

I: So why isn't this a NIII force pair? —

P: That's each force has an equal and opposite reaction force — that's internal. Okay — (IA) so the weight is 1.5 times 9.8 [gets calculator] — *which is 14.7 —*

I: … So you said the normal is equal to the weight —

P: Oh actually I guess we have T sine theta — so that plus the normal equals weight. So we have T sine theta plus normal equals mg so (IA) [Pink performs the calculation] — *so the normal force is 10.4 Newtons and then the kinetic friction — … T cosine theta plus the friction is going to equal mass times acceleration. (IA) … I guess it is a constant —* [Rereads problem] *(IA) So acceleration along the x direction is going to be zero because it is constant — … wait the force is constant so the acceleration is constant. So it is zero.*

I: Why do you say zero?

P: I don't know — that doesn't make sense … I was saying that the force was constant so the acceleration was constant but that doesn't make that zero. [Pause] —

I: It looks like you wanted to say zero — why did you ant to say zero?

P: Cause I don't know this (IA) but even if it is zero that would make that negative …

I: You said this force was in the opposite direction?

P: Yeah.

I: So if you add this force to this force [points to T cosine theta and force of friction in equation] — *is this ever going to be zero?*

P: When it stops — When it gets to C the —

I: So when it gets to C —

P: The acceleration will be zero — …[Fixes signs in the NII equation by putting a negative sign in front of the force or friction.]

I: How did you know that was going to be minus —

P: Because they are in opposite directions.

I: How did you know that the friction would be minus and not this force [T cosine theta]*?*

P: Well I could. (IA) … I don't know that the acceleration is — [Rereads] …

I: Anyway to figure out the acceleration?

P: I can't remember how —

I: So in the problem what information do we know?

P: we know the distance the angle — the tension — …

I: And what is the block doing? It starts off at rest —

P: Starts off at rest — speeds up — and then slows down — I know acceleration is velocity over time …Work equals force times distance

I: How does the work to get the block from point A to point B compare to the work to get the block from point C to point D?

P: They are equal — … because the force pulling it from A to B is the same and the distance is the same.

I: Which force? —

P: The tension is the same pulling it from A to B as B to C — … but I guess the work is more — it takes more work to go from B to C … because friction is applying a force in the opposite direction.

I: Which force is doing work on the block to get it from A to C?

P: Well tension and friction — … It's just tension from A to B.

I: Remember the Work-Energy theorem — [pause] *work equals change KE.*

P: Force times the distance is ½ m v squared. [pause] … *force equals mass times acceleration times distance which is the work and that equals 1/2 times the mass times the final velocity squared. — so between A and B the final velocity is —* [pause]

I: How does the change in kinetic energy from A to B compare to the change in kinetic energy from B to C?

P: … The change in kinetic energy from A to B is going to be 1/2 times the mass times the velocity and from B to C — its going to be — well you're staring out with a velocity so — They will be the same because you are starting from rest and you get to a final v and that is the initial velocity from here to here and you're stopping. So the velocity is the same and the mass is the same so the change in kinetic energy is the same.

I: does that help — [pause] *so you said that the change in kinetic energy is the same —*

P: So the acceleration is zero.

I: So how do you get that?

P: Because it is not acceleration … because it is not accelerating because the velocity is not changing.

I: What do you mean the velocity is not —

P: Well, it is starting and ending at the same velocity so the change in the velocity is zero — and the acceleration is change in velocity over change in time so its zero.

I: So you said acceleration is zero because it starts off at rest and it ends at rest … so the change in velocity from A to …

P: A to C is zero —

[Pink then proceeds to solve the problem, setting the sum of forces equal to zero. She therefore has $T \cos\theta - \mu_k n = 0$ and gets $\mu_k = .24$. She then tries to move on to the next part.]

I: This equation here — this F cosine 60 plus the force of friction equals ma — when does this equation apply?

P: Between B and C.

I: Between B and C— so between B and C —

P: And between A and B it is just T cosine theta.

I: T cos equals —

P: Mass times acceleration.

I: … Can you write sum of the forces in the x direction between A and B?

P: … It's just T cosine theta cause that is the only force in the x direction.

I: And that's equal to ma?

P: Yeah —

I: And the acceleration?

P: Well, it's going to be … cause it starts from rest and its got a final velocity at B so its just change in velocity over change in time.

I: So it is accelerating —

P: Between A and B — and its decelerating between B and C.

I: … so when you wrote this equation here [points to $T \cos\theta - F_r = ma$] — *this is for — you said this is for the part of the motion between B and C?*

P: Yeah — So if you have … I guess if you add T cosine theta then it would be for the whole thing

I: Say that again.

P: If you add T cosine theta again that would add all the forces in the x direction from here to that [points to A and C]. *So this would be* [writes a 2 in front of the tension force — she has therefore changed $T \cos \theta - \mu_k n = ma$ into $2 T \cos \theta - \mu_k n = ma$]

I: so you would get 2 T … so what is this equation again?

P: If we add T cosine theta — that's the forces between A and B plus the forces between B and C it would be the whole thing.

I: So what do you mean the whole thing?

P: I mean the sum of the forces … from A to C.

I: The sum of the forces from A through C is this guy [points to $2T\cos\theta - \mu_k = ma$.]

P: Right.

I: Now why do you say that?

P: Its just the sum of the force from A to B plus the forces from B to C.

I: So when you say this [points to $2T\cos\theta - \mu_k = ma$] *what's the acceleration?*

P: Well, there it is zero.

I: There its zero because . . .

P: Because the change in velocity over the change in time is zero —

I: … So, is it zero here? [Points to old sum of forces from B to C which is $T\cos\theta - F_r = ma$.]

P: Umm — That's between B and C — well it's decelerating so it can't be zero.

d) Reads question.

P: Work is force times distance and from A to C we said that — the work is done in the x direction because it moves in the x direction — the work between A and B is going to be T cosine theta times 1 meter cause the distance is one meter and between B and C it is going to be T cosine theta minus friction times 1 m — and it is just going to be those two added together —

I: And what work is this?

P: This is between A and C —

I: By what force? —

P: Tension … Tension plus friction from B to C —

I: So this is the work done by —

P: the work done by the sum of the forces … [Rereads question] *From friction from A to B it is zero and from B to C it is just μ times the normal force times the distance so its (IA) …* [writes answer].

"Michelle" (5/9/97)

(reads question)

a) Draw a free-body diagram for the block when it's between B and C.

M: Between B and C you have weight of the block times gravity — you have constant tension force at angle alpha and your going to have friction between B and C — and a normal force from the table.

b) Is the magnitude of the net force acting on the block from A to B greater than, less than, or equal to the magnitude of the net force acting on the block from B to C? Explain your reasoning.

M: Net force from A to B is greater than net force from b to c because there is no friction from A to B.

I: So why does having no friction mean —

M: You're looking at horizontal forces so tension is off to the right and without friction this would be gone … the friction cancels out part of the tension force.

c) Calculate the coefficient of kinetic friction between the surface and the block between B and C if $\Theta=60^o$, $m_{block}=1.5kg$, and T=5N.

M: Friction — I usually start with any definition or formula I can think of — so that is μ N and in this case it is not moving off the table or surface so you are going to have the normal plus the Tension times sine theta will equal m of the block times gravity. And we can solve for N so we can put in this equation [points to μ N = F_r] *— They give us mass of block — is 1.5 times 9.8 meters per second squared minus the tension which is 5 N times sine sixty degrees. … I'd get a number for this and plug that in here* [points to $\mu N = F_r$] *— Friction — because it is going to come to a stop at point C you are going to take friction at rest will be equal to tension times cosine of theta. … Because at the end it is going to be at rest so it is not going to be moving in the horizontal direction — I took that at point C.*

I: So you are saying that at point C the force of friction has to be equal to that [points to Tcos60] *because it is at rest.*

M: So they are equal — 5 N times cosine sixty — that will give me another number which can go into there [points to $\mu N = F_r$] *and I can solve for μ.*

I: … So at point C you said it was at rest so these two forces are equal?

M: Yes — I said it's got a velocity coming this way and the friction is eventually going to slow it to a stop and the μ isn't changing at all so —

I: So the acceleration at point C is what?

M: The acceleration at point C is zero because it is not moving.

d) Calculate the work done by friction to move the block from A to C. Show all work.

M: Start with a definition again — Work equals change in kinetic energy or Force dot distance — [pause] *I'm thinking — I'm using this one — I'm not sure that will work but I'll try it. Force and direction and distance are in the same direction so this is just force times distance.*

I: Which force?

M: The net force — which I haven't found yet. I am going to split it up between A and B and B and C because it is a different net force — So Work from A to B is —

I: How did you know it was a different net force?

M: A to B — the only force is going to be tension in the horizontal direction — so it's tension cosine theta times distance which is 1 meter which will be 5 N times cosine sixty — .5 times — 1 — will be 5/2 — work is in Joules — I usually check units if I have enough time — I do that with the homework. That is the work done from A to B. The work done from B to C is going to be the same tension force minus the friction force times distance — so that is going to be 5/2 minus this thing [points to F_r in the work form B to C equation] *— wait a second — I would get zero — I don't think that makes sense* [pause] *— I don't know —… That would be the final work done — it seems to me that there is more work done from B to C.*

I: Why do you say there is more work done from B to C?

M: — just because there is friction …

I: What work are you finding here?

M: That is just the work done by tension to pull it from A to B.

I: When you did the work from B to C — what work were you finding?

M: I took the net force — the work of the net force over that distance — I guess that could make sense because tension is pulling towards the right and friction is pulling towards the left so they cancel out — but I don't know if that cancels out work. …

I: So what is the net force in this [points in BC region] *region?*

M: There is still going to be some tension force — friction only cancels out at point C — it's not between B and C.

I: So the friction force and the T cosine sixty are equal at point C.

M: … I get μ from part C — no it will still get me the same thing — never mind — … I get zero — is that right — that's not right is it? —

I: … you said the friction force and the and the T cosine sixty are equal at point C — what about here [points to region in between B and C]*?*

M: Well friction stays the same because μ is not changing between B and C and neither is the normal — … friction is just taking away the momentum of the block — the velocity —

I: So are they equal here [points to region between B and C]*?*

M: Could be — I guess they are — because the tension's constant too and friction would be constant — so I'll leave it at zero then. …

I: How does the change in kinetic energy from A to B compare to the change in kinetic energy from B to C?

M: Well looking at this if work equals the change in kinetic energy I would get change in kinetic energy here is 5/2 and here it is zero. —

I: What do you think about that?

M: I would probably want to look at the formula for KE — ½ m v squared — KE initial would be zero because it started from rest so this is final and — this is from A to B [writes $\Delta KE_{AB} = ½\ m\ v_f^2$] *— change in KE from B to C — the final would be zero since it comes to rest minus KE initial which is at point B — mass is the same and the final velocity at B is the initial velocity so it is the same velocity — so the change in KE —* [writes $\Delta KE_{BC}= -1/2\ m\ v_f^2$] *so change in KE from A to C — if you add those two up you get zero. That conflicts with my earlier answer. I think there is something wrong with this* [points to equation for work — $W_{BC} = 0$ J] *— I think I should get — 5/2 J —*

I: How do you know that?

M: It has to be zero — this way tells you it has to be zero —

I: Knowing that — would you keep your answer to (b) the same?

M: I would think that is good — [pause] *The distance is the same and if the net work is the same that means the net force would have to be the same but opposite directions — which tells me that the friction is going to be greater than tension right here* [points to region between B and C] —

I: Does that make sense?

M: Yeah.

I: Why does that make sense?

M: From A to B you have no friction so you have the tension force off to the right and that's the net force from A to B and from B to C it has to be the same net force but is opposite directions so friction is going to have to cancel that out and double it to get the net force the same. …

I: The way you find μ *— is that ok?*

M: Probably not — the normal is alright. Friction is going to equal two times the tension cosine theta — …The net force from A to B is going to be tension cosine theta and because the works turn out to be zero — you are going to have the net force from B to C — it is going to have to be the same except in the opposite direction —

I: … before you looked at point C and said that the acceleration is zero there —

M: I guess I shouldn't have.

I: How does the acceleration here [points to C] *compare to the acceleration here —* [points to location between B and C]*?*

M: It is decelerating —

I: How about the magnitude?

M: The magnitude is greater here — … The easy answer is that it is moving forward and it eventually comes to a stop — if you look at NII the mass stays the same and the forces — friction is going to be slowing it down so the magnitude is going to be smaller hen it gets to C —

I: And then at point C — is it zero?

M: I’d say yes because it is not moving (IA).