1 Week 4

TA: So, I want you to take a look at this. This is a pendulum.

Wes: mmhmm. Ok. I thought you were going to draw a discontinuity in a graph and I was like 'aw, come on.'

TA: No, nono. We're not that cruel.

Wes: yeah.

TA: Whoa, that's a totally backwards M. Um. Well, that'll learn me...

Wes: Well, backwards to who?

00:37

TA: To the world. So, two forces on a single pendulum.

Wes: Mmhmm. More or less.

TA: The tension force, and the force due to gravity.

Wes: We get to neglect air resistance.

TA: We get to neglect air resistance.

Wes: That's crazy.

TA: Thank goodness. Ok, umm, so what we want to talk about today, we're not going to find an equation for the position of the system, with respect to time. But we're going to start along the path of finding an equation for the position with respect to time.

1:01

Wes: We're not going to find one?

TA: We're probably will run out of time before we find one.

Wes: Really?

TA: Yeah.

Wes: Kay.

TA: Yeah, 'cause we want to derive it, we don't just want to write it down and say, this is it.

Wes: Well, I know, I don't want want to derive it. But I've seen it derived.

Derek: We'll if you've seen it derived, you're more than welcome to do it.

TA: So, so, where would we start, along that path, guys?

Wes: [inaudible]...We could start with like, Newton's stuff, I guess.

REVIEW COPY NOT FOR DISTRIBUTION

TA: (hands Wes the marker)

Wes: Thanks.

TA: Show me what you mean.

1:37

Wes: Uh huh. (long pause)...um.

Derek: Start with Newton's Second Law. It's two points on every question.

Wes: Mmkay.

TA: You can write what's 'up' for you. You don't have to write 'up' for the camera. This is [oriented] just so you both could see it.

Wes: Okay. This is consistent.

Derek: Sure.

TA: Ok.

Wes: Yeah, well, mmkay. This squiggly over here (draws the sigma in front of F). (pause) um. That points...can't we just use energy? (laughs)

TA: No, energy's not going to tell you the position with respect to time.

Derek: That's ok, it gives us the energy of the system.

TA: It does, it does. But that doesn't help you if you want to know where it is at a given time.

(pause)

Wes: Why not?

Derek: Because it just won't. Energy doesn't work that way.

2:45

(laughs)

Derek: you can tell how far it's moved, I think. I think you could do that, but I don't think you could find position.

Wes: So it has some sort of mass, obviously.

Derek: Yeah.

Wes: It has an arc. (pause) arc length. (pause) vs. time.(pause)

3:10

(Derek laughs)

Wes: What?

Derek: Kay.

Wes: I'm just going through stuff in my head.

Derek: Alright.

TA: No, that's good.

Derek: That's fine.

(pause)

TA: So you wrote down Newton's Second Law, here.

Wes: Yes.

TA: What would be the next step in applying that?

Derek: Figuring out what all the forces are. And I think that's what he's trying to do.

TA: Mmkay.

3:33

Wes: Yeah, so? Sure. We'll do that. (pause) At what point?

Derek: At any given point.

Wes: They're different angles.

Derek: Tension is still tension. (pause) What are the tangential forces?

Wes: So sum of forces at 'time start'?

Derek: At any given time it's still going to have a tension force.

3:59

Wes: Well, at any given time, you have a theta and an Fg.

Derek: I didn't say they were equal! I said that they are forces.

Wes: I know! (draws) that's at any given point.

Derek: Mmhmm.

TA: Mmkay.

Wes: Mmkay. Well if you want to sum forces at it like you're going straight down as opposed to...

(pause)

Derek: The force is still going to be the force, no matter what. (pause) And...since there's only two forces acting on it, we can assume that t should always equal F of g.

TA: Why is that?

Derek: No, I'm sorry.

4:45

TA: Why's it wrong?

Wes: Is it wrong? Is it really wrong?

Derek: Yes, it's wrong. 'Cause there's acceleration.

(Pause while Wes draws)

Derek: Yeah, anybody can draw a line that makes it look longer.

Wes: No, all I was saying is Fg is over here, it's not over there. Which, just, is obviously what you said.

5:10

Derek: Yeah.

Wes: BUBBYE! (Erases)

Derek: No, there's acceleration, therefore it has to...

Wes: What's the letter for the period?

TA and Derek: T.

Wes: Little t or big T?

Derek: Does it make a difference?

TA: Big T, usually, by convention.

Wes: Just...

Derek: Sure. But we've already defined big T as being the tangential...

Wes: So what?...well, we'll just add 'force'. (writes) Kay?

TA: Mmkay.

Wes: Okay.

Derek; Uhh

5:45

TA: So, let's look back at, at Newton's Second Law, here. It sounds to me like, like you think this is the way to go, but you're having trouble figuring out how to add the forces.

Derek: What he's trying to do is figure out how to express the tangential force.

TA: What coordinate system are you using?

6:07

(Pause)

TA: Let's make one.

Wes: I'm not using any.

TA: Do you need to have a coordinate system?

Wes: No.

Derek: She's asking, therefore we probably do. Remember, this is their whole trick to try to get you to second guess yourself. That's all these tutorials are.

Wes: (points) He loves this. We may not use it. (Draws cartesian coordinates) Jeezum crow, that's an x.

6:34

Derek: Out of curiosity, why not use polar?

Wes: Eh?

Derek: Why not use polar? We're dealing with angles that are changing?

Wes: We're going to deal with T, we're going to deal with this, L.

Derek: Right, that's all constant, though.

Wes: Yes, and those are the only things in it. There's not even mass in it.

Derek: Mass...technically...[inaudible].

Wes: Yeah.

Derek: No it won't.

7:00

TA: I, I'm, mmkay.

Derek: If we use a polar coordinate system, all the r...all the radii from the various points, are just going to be constant. The only thing that's ever going to change in this is angle.

Wes: Radii? Yes. [inaudible].

Derek: Makes the math easier.

Wes: I'll use the eraser, so my hands don't get black. (erases). (draws polar coordinates) Here's theta, this is an r. Does it really matter?

Derek: No.

Wes: Good. Umm...We can define this though, right? Length?

TA: Yeah, you can call that L, that's ok.

7:44

Wes: That's good. So you would want an equation that is any position in terms of time.

TA: Well...the position of the...yeah.

Wes: The position of this–

TA: In terms of time, yeah.

Wes: Now, do you want position in terms of this way (gestures horizontally on the diagram)? Or this...

Derek: Do you want like x,y position?

TA: All, all I want to be able to do is tell you where it is–

Derek: It's much easier to use angles.

TA: –at any time.

Wes: Yeah.

Derek: Hence, why it's easier to use angles.

Wes: To just know where it is. Totally.

TA: Yeah.

Wes: Mmkay.

8:19

Wes: What's the...(pause)

TA: Tell me more about this coordinate system you, you set up here.

Wes: Just polar.

TA: Kay....What direction is the–

Wes: Positive.

TA: In this picture? Yeah, which way is it.

Wes: This is positive theta. Counterclockwise.

TA: Which way is this, r.

Wes: r is (gestures to the pendulum string on the diagram). If–what?

Derek: It really doesn't make a difference how you define it.

TA: I–

Wes: Well–

TA: I'm just curious–

Derek: I'm just saying.

TA: How you defined it.

Wes: Or-i-gin (writes).

TA: Okay.

Wes: And there's that angle there.

TA: Sure.

Derek: Sure, works for me.

8:58

(pause)

Derek: As long as it's defined.

TA: So, which way is r hat?

(pause)

Wes: Opposite t hat? T sub F hat?

TA: Mmkay, so...r hat is pointing out?

Derek: Yeah.

TA: Okay.

Derek: Points away from this surface.

TA: Okay.

Wes: [inaudible, includes the word surface].

Derek: She didn't define it being a wall or whatever. Which means this could be a magnetic situation.

(pause)

9:36

Derek: [inaudible, includes the word puppy].

(pause)

TA: Okay. Which way is, which way is theta hat in this situation? I see a theta.

Wes: Mmhmm.

TA: Positive theta.

Wes: It's counterclockwise. Yeah, counterclockwise. (pause) umm.

10:00

Wes: Now, me just thinking about this. The only connections I've made so far is, if I wanted to find a ratio between... (long pause. To 10:45) Um, time and, we say it started at some angle, right?

TA: Sure.

Wes: It's just like a, yeah, it's gonna be some sort of sinusoidal pattern. I would need, eventually, a ratio between... this length here...and...so you know i'm just trying to think what it would depend on. I mean, if we're neglecting air resistance and mass wouldn't matter.

Derek: Mass is going to make a difference.

11:29

Wes: It is?

Derek: Yeah. (Pause) [PHY] 121. Root mg over L.

Wes: For what?

Derek: For, ah, period.

Wes: Really?

Derek: Yeah.

Wes: That's T (writes the formula on the board)

Derek: That's probably wrong, I just remembered that equation.

12:00

Wes: Is it root–

TA: How can we check to see, is there a quick check we could do that would tell us if that would be reasonable or not?

(pause)

Derek: Actually it might...let me see that for a second. (grabs marker). We do–

TA: We're kind of getting down–definitely off topic, so I'm going to pull you guys back in. Talk about this coordinate system some more, cause i think....I'm just a little confused. Could you draw me like a little–

Wes: Does it even matter?

TA: I don't know. Does it matter?

Derek: See, it's this entire process to get us to second guess ourselves.

TA: I'm just curious about how you guys have a, have it set up here.

Wes: I would say if we had it in the traditional x,y, I just don't know where to go from...the start point.

TA: Okay. (long pause). How about if we have it polar, do you you know where to...

13:00

Wes: I would just break it down into friggin, um, arc lengths. Kinematics equations with forces and do some trig.

Derek: So do it.

Wes: And work out all the math. Hey, I don't want to work out all the math. Goddammit (grabs marker). Well, let's say this is L and say this is here, and this is a triangle, and that's a right angle, and that's some other distance I'm not going to name, yet, cause I don't feel like it. But...this is our theta up here. The sine theta...(writes). Yes, no?

Derek: Mmhmm.

Wes: Okay.

13:53

Wes: So we've got these distances. And...

Derek: [inaudible]...L is a constant. That's fine. [inaudible]

Wes: Mmkay. And, uh, we say our starting height (pause) is whatever distance, L minus this. That's our starting displacement from wherever it's going to be at the bottom. Then I'd use energy and figure out what its speed would be at the bottom. But... we'll stay away from energy, I guess. (pause) Cause my mind's trying to be connected to...we want something to tell its position with respect to time. (pause. 15:00) And if you want position in x,y, then, it's gonna be...stupid to do. To try. It would be easier to do position as opposed to angle of displacement. (hands marker to Derek, who begins writing)

TA: Does uh–

Wes: Rest point.

TA: Does a position based on angle and how far you are away give you the same information as it's x,y coordinates.

Wes: Well I can't think of any way to put it in terms of– you want what's this point. What are it's coordinates at this point?

TA: 'Where is it?' 'Where is it?'

Wes: But you'd have to do that in terms of coordinates, right?

TA: Sure.

Wes: Sure.

TA: That's–

Wes: And, uh...so I would say I don't know any functions that would give you out two parameters.

TA: Mmkay.

Wes: At the same time. [inaudible] I mean, you could base it on y and say ok and then plug it into a different equation and get your x.

TA: Okay.

16:00

Wes: If you want a specific point, I would almost want to take the route of what's it's angle of displacement. But,

TA: Would displacement tell you exactly where it was? At any time?

Wes: Huh? Well, no, you'd have to figure that out. But,

TA: Wh- are you? Sorry, you're doing analysis over here, are you finding you have...

Derek: That's wrong (gesturing to his writing).

TA: That's wrong, ok. Does it give you out seconds?

Derek: If you manipulate a few things, it will do it. Ah, it's Lm over g.

Wes: Lm over g?

Derek: Yeah, in order to get time.

Wes: Really?

Derek: Yeah.

Wes: Well, ok. Lg over m.

Derek: Sorry. That was going to irritate me until I figure it out, so I had to.

TA: Alright.

Wes: Do you know of any equations that will answer the questions of where exactly it will be with respect to time.

TA: So, we're kind of talking about–

Derek: Oh, no. I'm listening to you guys, too.

TA: So, I haven't heard your wording. So just knowing the angle, is that enough to tell us where it is, at any given time? What do you think?

Derek: Well, if he knows the angle and it's based on polar coordinates, yes, he'll know where it is at any given angle. (pause) What?

TA: What do you think? He–you were saying...

Wes: I was only saying, if you want, cause you were questioning the coordinate system, it's ok to go back to x and y, but to give out an answer that's going to give a precise exact location in the x and y, you're not going to get a function that gives you both components at the same time. You can get one and plug it into a different equation for the other.

17:39

Derek: Right. That's why it's easier just to–

Wes: But in polar, if you want it's exact location, in space, you have to have it in reference to something.

Derek: The origin.

Wes: So if you have it referenced to the origin, you know that this length is going to be constant, which is r in this system, and so you could say it's anywhere there.

Derek: But if we consider this to be zero degrees.

Wes: Yeah

Derek: Then you can figure it out.

18:01

Wes: That's about as exact as you're going to get from one single equation.

Derek: Yeah.

(pause)

Wes: So I was trying to work backwards in my head, what the goal is, and work back, okay, based on that, what type of parameters are you going to have in your function, so.

TA: So I think we're about out of time.

18:30

2 Week 10

Wes: You know, I hate this problem.

TA: I'm sorry.

Wes: No, really.

TA: Okay. So, what's the first step, here.

Derek: To erase it and go home.

Wes: The first step? (Pause) Position on what axis, with respect to time?

TA: Any way that you can describe the position.

Wes: Kay, cause I tried it with radians and I got a non-integral–non-integrate-able integral. And then I stopped doing, put it down, and decided I never wanted to see this pendulum question again. So now that I see it again, I kind of almost don't want to do it at all.

00:45

TA: So you said you tried it using–

Wes: I tried it doing, first, the energies.

TA: Okay. I'll tell you that way, that's not the way to go.

Derek: No, it really isn't.

Wes: I stopped halfway doing it with, uh, I can't remember.

1:05

Derek: It's periodic motion, therefore we can assume a sinusoidal or e function. Oh, no. Not e function.

Wes: Ok, so let's pretend it's a sine function.

TA: So, first, first thing to do–

Wes: Like phase shift and stuff.

TA:–setting up a problem from scratch, would be to define a coordinate system.

(pause)

1:26

Derek: Sure.

(Wes begins writing)

Derek: Well, how are you defining one?

Wes: I don't know...doesn't matter cause i'm going to transpose it...

Derek: Well,

TA: x and x.

Wes: Yep. Nope. Positive and positive.

TA: Oh. Okay. What do you think about this coordinate system?

Derek: I don't like it. Why don't we, ah, set the coordinate system at...

Wes: To what?

Derek: So that–

Wes: Polar?

Derek: –the origin is at the point of the hinge? And so that one axis points at one maximum..direction and this axis points in the other one. If we have to, we can define our own coordinate system. We have the math to do that. It's a pain in the ass, I'll admit. But we can do it.

2:19

Wes: At one maximum? So then you're going to say at our initial problem is 90 degrees from maximum to maximum.

Derek: Even if it isn't, you can redefine your, ah, coordinate system–

Wes: So x and y are not–

TA: So you're going to make a coordinate system where the–

Wes: –not independent

TA:–axes aren't orthoganal.

Derek: No, they are orthoganal. You can–

Wes: Would you give it a second?

Derek: No, I don't listen to you, you know that.

Wes: I know. I'm saying if these maxima are not ninety degrees, then they're not orthoganal.

Derek: Right, you can define your own system, ah, coordinate system so that your x can go like that and your y can go like that (draws an acute angle).

TA: Okay. We could do that.

Derek: It's calc three. You did do this, yes?

Wes: More math. Yeah, I think we're taking this problem a little overboard. It should be–

3:08

Derek: Oh, I know we are. But...

Wes: This is the problem. I hate myself. Anyway. Okay, I'm back.

TA: Alright. So let's pick a coordinate system.

(pause)

Derek: Polar.

(Wes laughs)

TA: How would you define that here?

Derek: You have a given r that's constant.

Wes: Zero. R equals. What's the one with the squiggly line? Theta! equals zero.

TA: So. Draw.

Wes: (Writing) Theta equals zero.

TA: Kay.

Wes: This way. Our origin.

TA: Okay.

(pause) 3:57

TA: Which direction is positive theta?

Wes: Huh? uh. (writes)

Derek: Why don't we define...that works.

TA: Okay. (pause) So, what's the next step?

(long pause)

4:23

Wes: I don't like these whole step by step things.

Derek: So go ahead and just solve it, then.

TA: Yeah. When I say 'what's the next step', I mean proceed in the solution of the problem.

Wes: Why would we define the coordinate system...in fact, I hate polar.

Derek: Fine! Define it in cartesian.

Wes: I wouldn't define it in either, it's irrelevant.

TA: Okay. So,

Derek: So what are your variables.

Wes: I'd just write...I'd just write a sine equation.

Derek: How do you know what accurately defines it? How do you know it goes between ninety and negative ninety?

Wes: It doesn't, necessarily have to.

5:01

TA: So what would you do if you didn't know the answer was sinusoidal? The question was prove from first principles–

Wes: That–

TA: –what the position with respect to time was. If your first step wasn't to define a coordinate system. What would you do first?

(pause)

5:30

Wes: Maybe I'd draw a free body diagram.

TA: Okay. Sounds good. Let's draw a free body diagram.

Wes: (writing) That's an e, that's an f.

TA: Okay.

Wes: I'll take this as our starting position, right now.

TA: Okay.

Wes: (writing) Tension of string. I'll don't want to put r for rod.

TA: There's an s.

Derek: Tension is constant and e is constant.

Wes: Anything else? Wind resistance maybe?

TA: No

Wes: Damping?

TA: No no.

Derek: The way she says no to that makes me a little afraid.

TA: Let's keep it simple.

Wes: Magnet field this way? Aluminum ball?

TA: No.

6:20

Wes: Okay, free body diagram.

TA: Okay.

Wes: That's and F B D.

TA: Okay.

Wes: Umm. Kay. Now maybe we'll write an equation with the sum of the forces.

TA: Alright, sounds good. Are you happy with?

Derek: Sure. I'm not sure why he's giving me these smartass looks.

Wes: I have to! I have to bring you into the conversation somehow. So whether you're yelling at me or not. (Derek laughs 7:00). Okay. These no longer exist. That's our coordinate system. That's the origin.

TA: So, so now you want to choose a coordinate system.

Wes: Well, I don't want to write these in terms of theta and r. I can, but...but I don't wanna. That's an x. Um...

TA: Which coordinate is x?

7:30

Wes: (writing) x, y.

TA: Okay.

Wes: Tension in x... I mean...hold on. Tension times some angle.

TA: Can you define the angle in this picture?

Wes: Probably, would you like me to?

TA: Yes.

(Wes writes)

8:11

Derek: You have two forces called Ts?

Wes: I'm getting there. Um... this is Ts [inaudible] See, this is where I went last time. I didn't like myself.

TA: Do you agree with this, is this what you would do?

Derek: I don't know. Sure.

TA: What would you do?

8:45

Derek: I don't know. I mean it's as good a one as any. I don't see why not.

TA: Okay.

Wes: (writing) That's a sum, not an E.

TA: I just want to know that what's going on here is indicative.

Derek: Sure, why not?

Wes: I don't know what indicative means. I've heard it though. My brother would know, cause he's smarter than I am.

TA: Indicates, what both people think.

Wes: Indicative, indicates. I guess so. (writing) Uh, which direction, up and down? Okay. Fe minus, remember this is positive.

TA: Right. Okay.

9:25

Wes: (writing) Umm...Ts, this is an s. I hope I'm drawing these with some sort of.

TA: That's fine.

Wes: Ummkay. Now we have those.

(long pause to 10:13)

Wes: Sorry, I was just thinking.

TA: What were you thinking? Tell us.

Wes: Energy. But I'll ignore that, now.

TA: Okay. What do you think. Where would you go from here?

Derek: This is why I would have it in polar coordinates. Because then, we take (writing) sum of the forces equals ma, right? So, m d theta (writing)....I'm going to call this x....

TA: Can you say aloud what you're writing just so it gets...

Derek: Uh, yeah, just a second.... Alright, so yeah, just do simple, yeah, second law from right here, sum of the forces equal to ma. Sum of the forces in the x direction is equal to ma x. So, we just take m d theta squared in the x direction times m dt squared in...no, ah, wait, if we're doing this in polar, you don't need an x. So...equal to ma theta.

11:30
Wes: Sum of forces in theta.

Derek: Right.

Wes: Positive theta.

Derek: Then we just solve this equation. Which would be...

TA: Which direction on this picture, if you were in polar coordinates, what would your angle theta be?

Derek: Which one, this one?

TA: Yeah. In this picture.

Derek: That...

Wes: It's technically, for clarification, we want two different angles.

Derek: Actually, it would be this angle, right here. Cause, yeah...opposite angles.

Wes: Opposite interior.

Derek: Yeah.

TA: Mmkay. So if we call that theta.

Derek: Yeah.
12:10
TA: What's the theta direction?

[inaudible as Wes and Derek start speaking]

Wes: It gets confusing.

Derek: That's zero degrees, and theta goes in this direction.

TA: So with this, so if I asked you do draw a, ah, a coordinate system and asked you to draw the unit vectors, what direction would the theta unit vector point?

Derek: That's why I have to keep the x's out. Okay. That's fine.

TA: Uh.

Derek: Well. (pause) Theta has to point in this direction.

TA: Can you draw that in the diagram?

13:09

Derek: So theta at this point.

Wes: Whoa whoa, a unit vector for what?

TA: To describe the direction of the theta coordinate.

Derek: It moves...It moves parallel to the path...of the motion–of the object.

TA: Do you buy that?

Wes: Yeah, I buy it, but that's not...

Derek: No, by what she just said, we've done something wrong. So.

Wes: But that's–

Derek: No, that's wrong, it's wrong.

Wes: What?

Derek: No, it's wrong.

Wes: Will you shut up?

Derek: No, it's wrong.

Wes: Positive theta, yes is exactly where this object moves. But I was just curious. The unit vector for theta. It's like asking a unit vector for x in cartesian.

14:00

Derek: Unit vector for x moves in the x direction.

TA: Okay, so..

Wes: So, to actually write it out, or draw it? Cause if you drew it, that's, that's what it is.

TA: Okay. That's, that's what I was asking, what's direction is theta.

Wes: Can you draw this in a little more artistic format?

TA: (writing) So if the mass is over here... and grew..

Wes: That's ok.

TA: What direction would theta hat be in this case.

Wes: Depending on initial conditions, it's either this way or it's this way. These are parallel.

(phone rings)

Wes: That's my phone, ignore that.

TA: Okay.

Wes: Who is that? Oh, it's some kid, I have to fix his computer. Anyway.

14:46

TA: So how do you know which direction theta hat is?

Wes: Now? Well, positive theta hat is that way.

Derek: So the unit vector would be in that direction.

TA: So what if the mass is heading back down toward equilibrium?

Derek: The unit vector is always positive, it just, but the value itself can be negative.

TA: Ok.

Derek: Multiplied by the unit vector.

TA: So it doesn't matter if the mass is moving this way or this way?

Derek: Right.

TA: Theta hat is always this way?

Wes: Well in that case–well...no.

TA: Well?

Wes: Okay.

Derek: Just think of i hat, k hat and j hat. Those are always positive. In the positive direction, the value or magnitude of it can be negative, though.

15:36

Wes: Well, yeah, in that case, it's either way.

TA: So you're saying it's in one direction, but you're saying it's either way.

Wes: No he's saying it's either way and I'm saying I agree with him–

Derek: No

Wes: –even though I accidentally wrote it this way.

Derek: It's always in one direction. The unit vector's always in one direction. The coefficients of it can be a negative. Which make it point in the other direction. Make the actual vector point in a different direction.

16:08

Wes: Well, i hat, just i hat, is one direction?

Derek: Yeah, have you ever seen it point in another direction?

Wes: (shrugs) Yeah. Anyways, we have this, this positive i hat, so you're saying i hat is just this way–

Derek: Yeah.

Wes: and if you want to make it negative, you put negative on i hat–

Derek: Right.

Wes: –and it goes this way.

Derek: Which is technically negative one times i hat.

Wes: Well, yeah. So why the hell would you say it doesn't matter?

Derek: I didn't say it doesn't matter.

Wes: Yes, you did. Kay, forget it. End of discussion. We're agreeing with each other. This is positive i hat. I mean, uh, theta hat. Yeah, ok.

TA: So, positive theta hat always is–

Wes: –that way.

TA: –this way. Always this way.

Wes: Yeah.

TA: Ok. (pause) So.

Derek: So, um.

Wes: We need gravity.

Derek: (pointing to his solution steps) No that's wrong.

17:03

Wes: Why?

Derek: Because it doesn't have all the terms in it.

Wes: I know that.

TA: Is there any tension in the theta hat direction?

Derek: No, tension's always perpendicular.

Wes: Really? Wow...that would make sense. Anyway. Sum of the forces, which you took out your little theta...

TA: Which way is the r hat direction?

Wes: What's r?

(pause)

Derek: What the hell you smoking, boy?

Wes: This r?

Derek: Yes.

Wes: r hat.

17:57

Derek: I'll give you a hint, it's in the same direction, where we pointed zero. Where it used to be.

Wes: I don't want it to be.

Derek: It's what you drew. It'll be your y.

Wes: Isn't it in all directions?

(pause)

Derek: No. (pause) It points downward. This way it makes gravity really easy to figure out.

Wes: That, so r hat should point here.

Derek: Right.

Wes: (writing) This is r hat. That's a hat.

TA: So does the direction of r hat ever change?

Derek: No.

TA: Does the direction of theta hat ever change?

Derek: No.

Wes: Guess not.

TA: Right here you have theta hat pointing this way, and here you have theta hat pointing this way.

Wes: Doesn't change.

Derek: In a polar coordinate–

TA: This way isn't a different direction than this way?

Wes: The universe is spinning this way, so.

(pause)

19:09

Wes: So, yeah...I just... Yes, the direction's changing.

TA: But not for r hat.

Wes: I guess not, yeah.

TA: You guys both agree on that?

Derek: Sure.

Wes: No.

TA: No?

Wes: No, I say that r hat is whatever direction it needs to be at that point.

TA: So you would say, which direction would you say r hat was?

Wes: It's in all directions, radially outward, at the same time.

TA: Okay. And you're saying r hat is just down.

Derek: Sure. This is why I like lectures. I don't like tutorials.

Wes: You don't like tutorials?

Derek: No. You're guessing.

Wes: Yes, I'm making educated guesses. On what I know. If I get proved wrong, I've learned something.

Derek: Yeah, I've learned not to say anything.