S1: Yeah, two B; what is the charge of q1?

S2: OK, basically what I did was—is there a marker?

S3: Budget cut—no markers.

S2: I might need that, so I'm going to leave this. I used this equation, like F k q big Q over r squared, for...

S1: That's Coulomb's Law.

S2: Yeah, the Coulomb's Law, or whatever, let me look at the problem actually, and basically you know that, I figured out what the charge difference would be. Like if q was attracted by like this this charge and this charge I would add them both together and that would determine what the net force was. So, basically for this interaction I just set values for everything, like I set this distance equal to .2 this one equal to .15 or something, and assigned these two a charge that was exactly the same and this charge like a little bit less—it doesn't matter. And, in the way it came out was that the one the has the smaller distance that this attracts it greater—has a greater force of attraction towards it. I mean—and it's pulling it like in a positive direction, because of the attraction it has, where this one had a smaller force and it's pulling it in a negative direction, so you add those two together it's going to determine a positive net force. Pulling it in the positive direction. Does that make any sense?

S4: Yeah.

S2: OK.

S4: [to **S3**] You understand this stuff now?

S3: Huh?

S4: How do you feel about that?

S3: EEAAHH?!

S2: It's hard to explain, like you might just have to look at it.

S3: No, I think I agree.

S2: Alright.

S3: I think I understand.

S4: So, you're saying the force is going to be moving...?

S2: Huh?

S4: The force is going to be moving with what side?

S2: To the right.

S1: To the right.

S4: So let's say this guy you move it here...

S2: No it's saying that in the problem—ok, here's what you're starting with. Say it's like this. And, these two—these are like x.

S4: Yeah.

S2: Right. And, now there giving you a new situation, in which like say this is ok...ok...so the distance between it's changing, so this was x minus two and this is x plus two, it's gaining whatever this is losing, because the whole distance is staying the same. So, you just have to like determine that—basically like the way I figured it out is that you determine the forces between these two particles. This is big positive force.

S4: Yeah. Yeah.

S2: And, then when you determine between these two particles it's a smaller, it's a smaller value than this but because this is a negative term this is a positive it's pulling it in the left direction, which is the negative direction so it's a small negative. And, when you add like a big positive to a small negative it's will produce a positive force. Which is the net force pulling it this way. Does that make sense?

S4: Alright.

S3: That makes more sense.

S1: The diagram helps.

S2: The diagrams...visual display.

S1: It's aesthetically pleasing.

S2: OK, so q 3 there's no forces acting on it, or no net force?

S1: No net force.

S3: Which means there are forces on it...

S2: The charge q2 has a value...

S1: We got two a b.

S2: Oh, do you guys understand or do you want me to...

S1: I understand.

S2: [to **S3**] Do you?

S3: I think so.

S2: Do you understand two B? Yes, ok. So, let's go to two big B. Three charge blah blah blah.

S3: My reasoning with this one...

S2: The charges q1 and q2 are fixed, the charge three, the charge is free to move. But, like it can increase or decrease in charge, but it's staying the same? Is that...?

S3: No. q1 and q2 are fixed in space.

S2: Oh, distances?

S1: Yeah. They're like stuck there.

S3: And, then q3 just happened to float along and is like chilling out by q2.

S2: OK, and then what's with the value of charge of q1?

S1: That sounds like this should be an MCAT question or something. (6:55)

S2: Yeah. Well, the distance between q1 and q2 and q2 and q3, they're the same, right?

S3: Yeah. I'm assuming so, since they're both d.

S2: I'm thinking that the charge q1 must have it's...negative Q.

S3: We thought it would be twice as much, because it can't repel q2, because they're fixed. But, it's repelling in such a way that it's keeping q3 there.

S1: Yeah. It has to—

S2: Wait say that.

S3: Like—q2 is—q2 is pushing this way, or attracting—whichever. There's a certain force between two Q, or q2 that's attracting.

S2: q3.

S3: But at the same time you have q1 repelling q3.

S2: How is it repelling when it's got this charge in the middle?

S3: Cause it's still acting. Like if it's bigger, than q2 it can still, because they're fixed. This isn't going to move to it's equilibrium point. So, it could be being pushed this way.

S2: Oh, I see what you're saying.

S3: Or, pulled. You know, it could be being pulled more, but it's not moving.

S2: Um-huh.

S3: So, we—we were thinking it was like negative two Q or something like that.

S1: Yeah. Cause it has to be like big enough to push away.

S3: [to **S4**](?)

S2: Push away q3.

S1: Yeah, which we—which I figured out negative two.

S2: Cause it's twice the distance away than q2 is?

S1: Yeah.

S2: I agree with that.

S4: Yeah, I mean it kinda makes sense. This—

S3: Did you run that?

S4: This one's positive.

S3: Did you run the marine corps marathon?

S4: Yeah.

S3: Cool. My dad has (?) those. He has all the...

S2: Did you go like this past year and do it?

S4: No, I did it two years ago. My sister, she got into running, so I just wanted to become, like you know, an athlete or nothing like that. I do a lot of cycling and running, too. So, I did it one time but I'm never going to do it again.

S2: Oh!

S1: Twenty-six miles.

S3: Still that's pretty cool.

S1: My goal is to do it when I'm twenty-six.

S2: My friend still wants to do it. (8:49)She's like working out like crazy. She's so like buff now. I mean she was always like skinny, but she's like you can tell she's like a big runner. She's at the gym—she's there forever. I'm like how do you have time for this?

S1: Yeah.

[off task]

(9:00)

S4: (?) If this one—this one should be negative and this one could be negative, so it would just like repel it.

S3: That's true.

S1: What?

S2: But, it's ge...

S3: Well, it could...

S4: Or, they both can be positive, they're just like repelling.

S3: It makes that—this problem impossible. If they're like—like if we have—maybe this is positive and these two are negative, or these two are negative and this is positive.

S1: No, see the negative signs just mean the opposite of. So, like...

S4: (?)

S2: You don't even have to assign signs. Like...

S1: Yeah. Whatever sign that q2 is, q1 has to be opposite and twice that.

S4: OK.

S1: So, it also has to be...

S2: Why hey —why does it have to be opposite?

S3: But, not necessarily. q1 and q2 can both be negative since they're fixed and then q3 can be a really big positive.

S2: But, if q3 were a big positive it'd be stuck to q2.

S3: I mean...or, I don't know.

S2: Like they'd all have the same charge.

S1: Like...

S3: I guess that makes sense. Then you know q2 and q3 can't be...

S1: Think of them as like constants. Like negative two and then this as a positive one and this as a negative one. And, then q could be a negative or positive number. And, you just multiply by negative two. Or...one or whatever. I don't know. It makes to me.

S3: What time is it?

S2: I don't know. I got to get out—right—

S1: It's three twenty.

S2: At three thirty I have to start writing my stuff down.

S3: I think I'm going to stick with my answer.

S2: (?) Are you a TA also?

TA: Yes.

S2: I have a question. I didn't know. OK on this problem, I feel like there's more than one possible answer.

TA: OK.

S2: Like they don't tell you anything about the charges, right?

S1: Yeah. They don't tell you anything about the charges. You just know that (11:16.0)this has—this feels no net force. So, if this one attracts this one, then this one also has to repel it.

S2: But it's not like—I feel like this q1 doesn't have much of an interaction with q3, because of q2 in the middle. Is that right to think that or does it still gonna have some effect on it?

TA: Why do you think that? I mean, what's your reason?

S1: Like why is it not going to have an effect on q3?

S2: I don't know. Maybe you're right. I guess like charge doesn't have to go in a horizontal line. It can go any where, right? And, this is free to move, so it can pull it this way. If it wanted to.

S1: Yeah, but since it's in equilibrium, it's not going to.

TA: So, you're saying that this doesn't on q3?

S2: No, it does.

TA: OK.

S2: I just didn't think about it, right. OK.

S1: So, do you understand how it works?

S2: Yes.

S1: OK.

S3: We always get the TAs over here and then have no point when they get here.

S2: I think they all have the same—I think they all have—I know! I'm like, sorry. I think they all have the same charge.

S1: You think they all have the same charge? Then they don't repel each other.

S2: Huh?

S1: Then they would all repel each other.

S2: That's what I think is happening.

S1: Yeah, but q3 is fixed. If it was being repelled—

S3: No, it's not. q3 is free to move.

S1: I mean, q3 is not fixed. That's what I meant.

S2: Right.

S1: So, like...

S2: So, the force of q2 is pushing away with is only equal to d.

S1: Yeah, but then...

S2: These two aren't moving.

S1: Wouldn't this push it somewhat?

S3: Just because they're not moving doesn't mean they're not exerting forces.

S2: I know.

S3: What do you think?

TA: Can I make a suggestion?

S2: Uh-huh.

TA: You guys are talking about like a lot of forces and stuff. And, one thing I've suggested in previous semesters, if you write it down and say, what forces do you think are acting here, you can all talk about it.

S2: Where did the marker go?

TA: That's a suggestion—a general suggestion that I might make.

S2: I need this.

S3: You don't need that.

S2: Huh?

S3: Do you need that?

S2: Possibly.

S3: Oh! OK.

S2: I don't know. I don't want to get rid of it.

S3: Tell me what the problem is. Do you need this?

S2: No. Do you guys need this?

TA: May or may not help, I don't. If you decide you don't want to do this in the future...

S3: Alright. So, what are we doing?

S2: Just draw it up there and then...I think it's just the fact that q1 and q2 are fixed, so you don't know what they would be doing if they weren't. You know what I mean?

S1: Ah, I thought about that. I was like, oh, what if they weren't fixed, well of course they don't (?).

S2: Right.

S1: What?!

S2: You're trying to figure out what q1 is, right?

S1: Oh, yeah.

S3: Because this is in equilibrium, there's some force...

S2: Pulling it that way and some force pulling ex—equally back on it.

S1: Yeah.

S3: And, there equal?

S1: Yes.

S2: Same with up and down. Not that that matters, really.

S1: We'll just stick with...

S2: Horizontal.

S1: Yeah, one dimension.

S3: So, maybe this is pushing...

S2: That's [q2] repelling and q1's attracting?

S1: Yeah, it's just that whatever q2 is, q1 has to be the opposite. Right?

S3: Not necessarily.

S2: Yeah.

S1: OK, like what if they were both positive?

S3: Well, I guess you're right, they do have to be different, because if they were both positive...

S1: Then, they'd both push the same way.

S3: And, if this were positive it would go zooming that way.

S2: They would both push.

S3: And, if this were negative it would go there.

S1: It would go zooming that way.

S3: And, if they were negative...

S2: It would still—they'd all go that way.

S3: It would be the same thing.

S1: Yeah, so whatever q2—

S2: So, they have to have opposite charges.

S1: q1 has to be at least opposite q2, and since it's twice as far away from q3 as q2, it has to be...

S2: Twice as big as the charge?

S1: Yeah. Negative two Q, since it's twice as far away.

S2: Negative two Q.

S3: Are we going to go with that?

S1: I think it makes sense.

S2: That makes...

S3: Well, I don't know, because when you're covering a distance you're using it in the denominator as the square.

S1: Oh! Is that how it works?

S3: And (?) makes a difference.

S1: Yeah, you're right.

TA: So, how do you know that?

S2: From the Coulomb's Law.

S1: So, it should actually be negative four q? Or what? Since it has...

S3: Cause we were getting into problems in the beginning of the problem with two A A, because I thought that like if you move this a little bit to the right the decrease for this would make up for the increase for this. But, then we decided it didn't. So, that's how I know that I don't think it would just increase it by a factor of two.

S2: Uh-huh. I see what you're saying.

S3: I guess it would be four.

S1: Yeah.

TA: So, what do we know—you drew some arrows there before. What were those arrows all about?

S2: The q3 is being held in an equilibrium that's why it's not moving.

S3: Yeah, so there's some push and there's some pull that's equal.

S2: Right, that's keeping it were it is.

TA: What are those pushing and pulls in terms of physics? Like...

S2: Attraction and repulsion. Basically.

S4: I said that you know if we—whatever force you know q2 exerting on q3 is q3 is exerting on q2. I mean they're the same and equal in force. So, whatever force q2 is that's what q3 is gonna be, 'cause I suppose they're in equilibrium, right? They're not doing anything.

S2: But, q3 can take into account what q1 is doing also.

TA: So, what forces does q3 react to?

S3: Both of these. Right?

S2: I think so.

TA: Right, in general, an object only only reacts to the forces that it feels.

S1: Right.

TA: Not necessarily forces that it can exert on other things.

S2: Uh-huh.

S3: So, (?)

S4: Yeah, I mean q3 doesn't know anything about q1, it only knows about q2.

TA: Why do you say that?

S2: Why?

S4: Huh?

TA: [S2 is] asking why. Why doesn't q3 know about q1?

S4: You know cause it's like, it—it cannot feel anything from q1. It can only (17:34.1) feels something from q2.

S3: I think charge is different, though. Like—like, like it's not like pushing. Well, it is pushing, but it's a different kind of pushing. You know what I mean?

S2: Like—like.

S3: Like if I was—

S2: Like a hydrogen molecule—think of it as if like water. I think water helps. Like cause y'know when...this is the oxygen and it's negative, and hydrogens are positive. Like if there was another water molecule coming...like this negative charge is felt by this. And—but it can come from anywhere. Like these negative charges can come this way. This positive charge attraction is not just like in one plane. It can come from anywhere. I think that's why like with q3 if it wanted to it could move towards q1, depending on how it interacted, but it's chosen to settle by q2. That's what you have to take into consideration. Like it could be any where.

TA: So, [S2] you're saying that—[S2] that's correct?

S2: Oh, that's [S3]. I'm [S2].

S3: That's [S2], I'm [S3]. You're close though.

TA: [S3], OK.

S2: It's alright.

TA: So, [S3]—if I understand this—[S3] you're saying that q3 can feel q1?

S2: Sure. Yeah.

TA: And, [S4] you're saying it can't?

S4: I mean the way it's drawn there [**S2**: It's deceiving] you're thinking the closest—the closest to q3 is q2.

TA: Because like q2 is like in the way. So, it can't feel it from q1.

S4: Cause I mean like the way it's drawn, I mean but now I see what you're saying. And, again it could come from like anywhere and I mean changed my mind now that she's said that. Y'know what I mean, yeah. That is like the way it's drawn there I would say I would say that, I mean like q2 has the strongest like force. It's keeping q3 in equilibrium. That's what the problem is saying, right?

TA: The problem is saying—

S2: It doesn't say what's keeping it in equilibrium, it just says that it's in equilibrium.

S4: Yeah.

S3: Well, you know that there's a balance of forces, so like...well, I don't know if q2 would necessarily be the stronger charge, because q1 has to cover some much more distance, which goes back to our point before.

S2: Uh-huh. But, distance might not have anything to do with it.

S3: I think it does. I could be wrong, though. I don't know.

TA: So, let's think about example—

S2: The greater distance away the smaller the force you have on it.

TA: did you guys do the thing with the tapes?

S3: Yeah.

TA: You did the thing with the tapes, right?

S2: Uh-huh.

TA: So, if you had the tapes far away did you see them attract to each other?

S2: No.

TA: If you brought them close to each other did you see them attract?

S2: Uh-huh.

S4: Oh, yeah.

TA: So, do you think distance matters?

S4: It does.

S2: Yeah, it does. But, like I think in that case, though, q1 going to have a small attraction to q3 because it's so far away. But, I mean, from the way q3 is just settled there, like if q3 was between q1 and q2 cause it could have been, you know, like it could go where ever it wanted. But, it chose to be there, so q1's having a weaker interaction on it. (20:25.7)

TA: But, one thing—I think...

S2: I don't know.

TA: [S2] was saying earlier that the forces had to be equal, is that what you were saying?

S3: Right. I think q1 is pushing. It's got cross more of a distance, so it's pushing like—its charge is bigger to cross that distance. Whereas, this doesn't have to go as far.

S2: Well, we just concluded from two A that that's not true.

S1: q1 could be pulling and q2 could be pushing.

S3: Yeah, I mean which ever.

S1: Yeah.

S3: It's doing some action and then q2—q2 doesn't have to exert as much force because it's closer. I think that's exactly what we talked about in two.

S1: Yeah. Which is why...

S2: No, I think it exerted more force, when it was closer. The interactions were stronger.

S3: Well, it's less of a charge, but it exerts—because it's less of a charge it can exert more force over that smaller distance.

S2: Less of a charge?

S3: Like it's smaller distance so it doesn't need as much charge to push with the same force.

TA: Do you guys buy that? Sonia's shaking her head and saying, 'yeah'.

S1: I understand. Yeah.

S3: I'm not explaining it as well as I think I should be, but...

S2: This is a frustrating problem.

S1: This problem looked so easy.

S2: I know.

S1: It's definitely an MCAT problem.

S2: Huh?

S1: It's definitely an MCAT-type problem.

S2: Yeah.

TA: So, yeah, where are we at—at this point in the problem? I'm...so...

S2: Still back at square one. I just feel like I don't know anything.

S3: We've established that there are forces acting on it.

TA: Let me try and summarize things that I've heard.

S2: OK.

TA: I heard that q1 is at a greater distance, so someone said that the charge on it had to be greater.

S1: Yeah.

TA: q2 is at a shorter distance compared to q1, so it could have smaller charge on it.

S3: Right.

TA: Everyone agrees on that. Those are things (22:15)that were said. Do we agree on these things?

S2: To an extent.

TA: OK, you said q1 was negative, because—so if q3 was positive q1 would be negative it would pull it. It would—it would sort of pull it to the left. And, q2 would push it to the right.

S3: Right. Or, it could be—yeah.

S2: Just depending on how the charge—it—that doesn't necessarily have to be how it is. Like—

TA: So, what other options do we have?

S2: q1 could be negative.

S3: These two could be positive, too.

S2: OK [tentatively].

S3: Because this would still feel the attraction to the positive, but it wouldn't be able to go all the way to the positive, because of the push from q1.

S1: What?

S2: Like, OK, I think I see what you're saying.

S3: Or, like these—it could be—

S2: Like, q1—q2 and q3 could have the same charge.

S1: Uh-huh.

S2: So, they repel each other. And, q1 could have the opposite charge of q2 and q3, which would attract it, but since it's so far away it doesn't come any closer to it.

S3: Or, q2 and q3 could have opposite charges and it could—it could be attracting, but it's still—yeah—but it's still like pushing each other.

S2: Two like big (23:17.5)B, the second part of two. I think there's a variety of answers to this question.

S1: Yeah.

S2: So, I'm going to say...like q2 and q3 are repelling, and q1 and q3 are attracting.

S3: But you don't know that.

S2: You don't, but you can assign values that way.

S1: We can just say that the mul—we could give like two different answers.

S3: Does that even answer the problem?

S2: It's asking (23:50) you what the—

S1: What we're trying to figure out is what's the coefficient for q1. Like, is negative two or negative four, or four or six. That's what (?) can't figure out.

S2: What must the charge q1—what value must the charge q1 have?

S1: Yeah.

TA: So, do you agree—

S2: Like Coulomb's law, like I'm trying to use that.

S3: I don't see why it has to be negative.

S1: Well, no.

S2: It doesn't have to be negative. It could be positive and q2 and q3 could be negative.

S1: Yeah, well the negative sign just means it's the opposite of whatever q is.

TA: What's the value of q2? Do we know?

S3: Q.

TA: Is it positive or negative?

S1: Yeah.

S3: It doesn't give positive or negative.

S2: It tells you q2 is equal to—Oh!

S3: I mean you could take it as being positive, but (?) coefficient—oh.

S4: Like, negative charges are like lighter than positive charges, so it has the tendency to like move, y'know, like have more electrostatic.

S2: I have no idea.

TA: Why do you say that? I mean if you're thinking about maybe electrons and protons you might think negatives are lighter.

S1: Just like electricity.

TA: In general, it doesn't necessarily have to be that way.

S4: So, q3 could be positive or negative than.

S1: Yeah, q3 could be positive or negative, but it looks like q1 is always the opposite of whatever q2 is.

TA: So, I have a question. Does it hurt us if we assume that q2 is some charge, positive or negative, it tells us it's Q, can we just assume that it's one of them?

S2: Yeah, that's what I'm trying to do.

TA: And, like q3 is one of them and then figure out which one q1 had to be.

S2: Yep.

S3: OK.

S2: So, I'm going—I'm going to assume that q2 is—

S1: One.

S3: Positive.

S2: Is positive.

S1: Positive?

S2: And, q3 is positive, too. So, they repel each other. And, that's going to account for this part of the equilibrium [right push]. So, then you got to account for this part [left push] of the equilibrium, which is what q1 is going to do. And, that's going to be...it's going to be opposite—have the opposite effect as q2, so it's going to be negative something q.

S1: Yeah. If you draw it the other way it'd still be negative something q.

S2: Yeah.

S4: Put the charge up there.

S1: That's what we're trying to figure out; how much the charge could be.

S2: We're trying to figure out—

S4: So, you're saying that q3 and q2, they're positive both?

S2: Yes.

S4: Two and three are positive, right?

S2: Yes. That's why I write my—

S3: q2 is pushing away, but q1 is pulling.

S2: Yes, but we—it's pulling by how much? Charge—what...How much is the question.

S3: Basically, all we have to figure out is how is this distance different from this distance.

S1: Yeah.

S2: But...

S1: Both the same distance, but how does that effect the charge?

S2: Like it's twice and they give a distance.

S1: Yeah. So, if you double the distance how does that effect the charge, like does it—do you have to have the charge twice as big or four times big?

S2: Where is that other problem? Three times as far apart as they were now what is the magnitude of the force?

S1: I think it should be four times.

S2: If it's three times as far apart it's...you divide...uh! I think it's q over two.

S1: Q over two? So, if you think of it as half the force of q2.

S2: Look at this one.

S1: Is this one you're talking about?

S2: Uh-huh. If you increase the distance that they are from each other it's decreasing by the same amount. I thought it was four (?), but they said it was (?). I don't know why. Just three times...does it matter? [talking to another table] I'm looking this one. Number three, isn't that like the same thing?

S3: Three was an estimation problem.

S2: No, no with the q and four q and all that, you know how there was this question that asked when you move the charges three times further apart than they originally were, what the resulting force is.

S3: OK.

S2: And, you said it was—we said it was four (?)—the charge would be like q, or nine, but it would got three times as far apart. Why it's not three I don't understand, but that alright. So—

S3: Well, 'cause in the equation you square this—the distance between them. Like if you're multiplying by three...

S2: Oh! So, I would think this one would be q over four—negative q over four. Cause it's twice as far away, opposite charge. Does that make sense?

S3: But, then it's a smaller charge than this.

S1: Yeah.

S3: So, I don't understand how it would be pushing three or pulling three whatever it's doing.

S2: Wait, let me see, where's the pen?

S1: You can use the eraser.

S2: Let me erase part of this. This is positive, this is positive. Negative, this is d and this is d.

S3: [to **S4**] I'm sorry.

S4: [inaudible]

S3: But, q1 and q2 are fixed...

S2: q3 can move.

S3: And, then, right—according to the diagram I'm assuming that these distances are the same, cause they're using the same...variable.

S4: Yeah.

S2: See what I did? I changed the denominater part.

S1: So... (32:11)we just said it's four q?

S2: I think it's negative q over four.

S1: What?

S2: I think it's negative q over four.

S1: Why would it be divided?

S2: Well, you're using this, like Coulomb's law. This would be like the force between—

S3: I don't know, because it's exerting the same force that this is exerting and this one like if you put it in and you put in one you'll get k q q, [S2: Oooh!] but to get—to get one with that you have to do negative four q up here and then the four would cancel out.

S1: Yeah, so that way the answer will be the same both ways.

S2: Wait.

S1: The same—

S2: Say that one more time.

S3: Alright. This exerting a force...

S2: Yep.

S3: And, then the force this is exerting this is feeling the same force. OK?

S2: Same magnitude as what—

S1: Yeah, same magnitude.

S2: Yeah, OK.

S3: So, then they cancel for it to be in equilibrium.

S2: Right.

S3: So, then say this is between two and three. Alright, you ignor—you make the distance one. That would give you constant times you know the two charges.

S2: Uh-huh.

S3: So, then if we go by your reasoning where you double the distance it would be two. So, you have all this under four.

S2: Yep.

S3: So, it's—

S2: But, you have to have four on top to cancel it.

S3: Right.

S2: That, so it's negative four q.

S3: [to S4] Does that make sense?

S4: Yeah, it sort of makes sense.

S2: All that work for like a two second answer.

S4: You know like the calculation's saying and it makes sense, but y'know, it's like is it right?

S3: [talking to some else at a different table.]

S2: OK, I get it.

S3: Go for it.

S2: Alright. We're saying that q2 and q3 have the same charge. So, this is repel...so this is pushing q3 this way, and since q3 is in equilibrium something's got to be pulling it this way; and that's gotta be q1. So, if—so like say say that like this distance or whatever is equal to one, like cause each of these is the same amount of distance between the two particles, from what the diagram said. So, these equal to one when you're doing like the distance between like q2 and q3 you get like some value over one. But, when you add these two together you get two as like when you're—the readings between q1 and q3 is two. And, when you have that over—and you plug it into that equation your distance is q—is two squared, which is four, so in order to like make this go away and equal to one, so that these two forces can be equal, so that this equilibrium holds true, you have to multiply by some multiple of four on top to cancel.

TA: You all agree with that?

S1: Yeah.

TA: OK.

S2: I don't know how I'm going to write this out though, in like two lines.

S1: Do you guys know how to do number three?

S2: Oh God! Number three took me forever.

S1: Really. I don't even know where to start.

S2: Alright, hang on.

S1: Oh, so you're writing like the paper that you have to hand in?

S2: Yeah, cause I don't have any time to do it later.

S1: Oh, are you going to the game?

S2: No, I can't I have class from seven to ten.

S1: Oh yeah.

S2: [off task]

S3: OK, I'm done with this problem.

S2: What did you write?

S3: Negative four q. And, then I did like something like what I just said. Like I set them equal to each other and put an x in front of the big q. So, like to make these equal you have to have a four in the numerator.

S2: OK. I don't know how to write this. q3 and q2 are positive, so q1...

S4: So, you think it's going to be negative four q, huh? In—in-ah—q2 is it four q?

S3: q2 is q, and then distance increases by a factor of two, so based on whatever reasoning with that, we figured it's going to increase by a factor four.

S2: Four times the im—it must exert four times the amount force as q2?

S3: The charge is going to be...

S2: Four times the amount of charge as q2?

S3: Sure.

S4: So, q2 q3 you'd say they're—they're—they have a force of two?

S3: Well, between q2 and q3 you have this, and then between q1 and q3 this is kinda how I wrote it. q3 you have...

S2: I just said assuming that q2 and q3 are positive, so q1 is negative. q1 must exert four times the amount of charge as q2, so that the F Q, force of q2 on q3 and force of q2—q1 on q3 are equal, helping q3 stay in equilibrium. Is that enough?

S1: You basically covered it.

S2: OK. What do you have a problem with number three?

S1: I don't know where to start.

S2: I just go back (?).

S1: Like I assuming we're using Coulomb's law, that's the only law that we've been taught. But, I'm not exactly sure how to use it. Like...

S2: Well, the—the balls aren't moving, right? So, what does that mean?

S1: They are—the net force—like they in equilibrium.

S2: Uh-huh. So, the net force is what?

S1: Zero.

S2: Right.

S1: So, F would be equal to zero for Coulomb's law?

S2: No. No. That—that's what I thought at first. But, the Coulomb's law doesn't tell you the net force, it just tells you how one's acting on the other. So, if you added the two together it would be zero. Does that make sense?

S1: Oh, the force of one

TA: What did you do there?

S3: What did I do there?

TA: Yeah, can I ask?

S3: Alright, so because this isn't moving the two forces that are acting on it are equal. The push and the pull. So, the F—I don't know if this is the right F symbol—but, the F q2 on q3 is equal to this. And, then the F q1 on q3 is equal to this, because the distance is twice as much, so it would be four d squared instead of d squared.

TA: OK.

S3: And, then I used x q like or you can even do—yeah—x q for the charge on q1, because we know in some way it's going to be related to q like the big q we just gotta find the factor that relates to that.

TA: OK.

S3: Then, I set them equal to each other, and I crossed out like the q2 and the k and the d squared and that gave me q equals x q over four. And, then x q equals four q, so x would have to be equal to four. That's how you it's four q.

TA: How did—why did you set it equal?

S3: Because, they're equal charges. Like these two have to cancel each other out for this to be in that equilibrium.

S1: Both should equal.

TA: Do you guys buy that?

S2: Yeah.

S1: Well, shouldn't it be—well equal and opposite, but...

S3: Yeah, you could stick the negative.

S1: Yeah.

S2: I didn't use Coulomb's equation, I just—but it was similiar to that.

S1: That's a good way of proving it.

S2: Uh-huh.

S1: Good explanation.

S3: Can I have my A now?

S1: Yeah, two weeks into the course.

S2: Alright, I'll just get you more in the right direction, then I have to head back. So, basically you know that the net force is equal to zero, and what you're trying to figure out is what this force is in between these two objects. They want to know. And, since they have the same mass, so what does that mean about the charges that they have?

S1: Probably equal charges.

S2: Uh-huh. So, basically, if you figure out the charge of one you figure out the charge of both. And, then way that we did this, we drew a force—

S3: Free-body diagram.

S2: Free-body diagram, yeah, I'm just kinda giving her the right direction. You draw a free-body diagram for one of the balls. You pick whichever one you want. And, the main thing you're trying to find is this—is this x value force that's pulling it away from the other. Because if they were—if they were—if there was no net force, they weren't moving, but there was no charge between them, they would just hang there. But, they're at this angle, so they're repelling each other. So, a long story short, you know that—you know the force down on this ball. Which is the weight of the earth. And, they give you how much it weights, so you can calculate the weight of the earth. That can also tell you—

S4: The weight of the earth? Or, is it just mg?

S3: No, mg.

S2: Yeah, mg, same thing.

S3: No. No, not the same thing.

S2: Weight of the earth on the ball?

S3: Weight of the—That's mg.

S2: Yeah.

S3: You were saying weight of the earth.

S2: Oh, I'm sorry.

S3: Do you have your protractor?

S2: What?

S3: Do you have your protractor?

S2: No, not with me. I don't know. You can figure that out, because like basically you—you have this tension force, too. And, that like makes this horizontal line-ish thing.

S1: Yeah. So, you have to just—

S2: And, I made—we made similar triangles, because if you could figure out this, then you could solve for um one of the sides and that will tell you—it should be bigger—it should be like all the way out here or whatever. But, it will tell you what this x length is if you use some sort of sine cosine relationship. And, use the forces to determine the sides. Don't use like—don't use the three centimeters to say how big the side is. Use the force. I don't know if I'm explaining this right, at all. So, like tell you how to do it without giving the whole answer away.

S1: Yeah, I know.

S3: Draw a free-body diagram and like keep on separating the forces. Basically.

S2: Yeah. Look at the forces—

S1: You know the forces on the ball are equivalent to the forces on the—

S2: You're going to know which force you have to find that's going to solve the problem, so based on what you do know figure out how you could find out what that force is. OK?

S1: OK.

S2: Alright. If you—yeah, if you can't figure it out I'm sure [S3] can help you, but...

S3: SOHCAHTOA

S1: What?

S3: SOHCAHTOA, trigonometry problem.

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