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Engineering Education

Interview #3

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Centripetal Force?

Background:

The friday before Halloween, a couple of my friends and I went to Screemfest at Canobie Lake Park. While they were amazed by the decor and haunted houses, I was more amazed by the roller coasters themselves. After a fascinating physics centered video and lesson at the end of class on the 24th of October, I could not help think about the physics behind each roller coaster. One specifically stuck in my mind. Zero Gravity. This ride is shaped like a giant circle. You get strapped in standing up straight and the roller coaster spins you rapidly in a circle. The floor drops, your heart sinks a little, and you seem to get stuck onto the ride. Literally stuck. I decided to ask how Zero Gravity works to a friend in my physics class who has never taken physics prior to coming to Tufts. I thought it would be interesting to see how someone would think about the physics principles and laws that would have to exist in order to make a ride like Zero Gravity or roller coasters in general possible. Since the student is neither an expert nor a pure novice, I wanted to see how their bag of tricks work. I decided to frame the whole interview as a conversation where I was simply curious about the scenario. I wanted to create a pressure free zone so that my interviewee would not hold anything back as compared to in the past when I immediately told my interviewee that I would end up revealing everything they said to my entire class. At the end, however, I did receive their permission to use their comments for my interview analysis.

https://www.youtube.com/watch?v=pcvDjJYou84 (skip to 0:30)

Question: How does rides like Zero Gravity work?

Interviewer: Q Interviewee: Friend from Physics Class

They requested to remain anonymous so in the transcript they will be known as “A”

Comments in italics

Analysis in Bold

Q: Have you ever been to Canobie?

“A”: No what’s that?

Q: It’s just an amusement park. I went there the other day and it’s just … there’s a ride that we went on that I’m trying to figure out how it works. At Canobie its called Zero Gravity. You like get strapped in standing up and the thing spins you wicked fast. Actually here I'll show you a video.

(shows the youtube video linked above)

"A": (mid-video) Ohhh yeah I've been on a ride like this. Except mine wasn't as big.

Q: Okay yeah, like why do you think we don't fall off when the floor drops or like you know your at the top of the ride facing down. Like if we don't fall off due to gravity, shouldn't we be at least flung off because we're spinning so fast.

Rather than asking directly asking my friend the question in a "I know the answer but you don't" fashion, I decided to incorporated myself into the conversation and imply that I am also unaware of the answer. This was the first step I took to try and frame a pressure free and conversational environment.

"A": Umm I guess. Hmm I've never really thought about how roller coasters work (laughs).

At this moment, not only does my friend laugh but they also sit back a little bit to think and relaxed their shoulders. This combination of gestures showed to me that they feel like they can be natural and that they might be framing the situation as I intended. Even though all these actions may seem like small gestures, I feel like if you are able to capture all these discrete changes in body behavior, it can really give you an insight into how one is feeling which directly correlates to how one may be thinking. For example, if someone is rapidly shaking their knees and refuse look at you directly in the eye then they are most likely feeling very nervous and all their answers are probably really fragmented or quick since they aren't thinking at a natural pace. This proves the importance of capturing every type of language during interviews rather than just speech.

“A”: But since we don’t fly off, it must be because of I don’t know … centripetal force. That’s a force right? Yeah yeah, v^2/r. Um I don’t really know exactly how that applies but I know that’s the formula you use when something travels in a circle path rather than linear.

v equals velocity and r equals radius.

Even though they were unsure of centripetal force being the correct answer, they still mentioned it. I wonder if it is because of how their framing of everything. If I originally told them that everything they say, wrong or right, will be shown to my class, I wonder how long it would take to mention centripetal force or if they would even mention centripetal force at all.

Q: Ahh centripetal force. Interesting.

I attempted to execute what Julia proposed of repeating your interviewee’s statement but it sounded really generic however it did turn out fine.

“A”: Yeah it’s just I don’t know exactly how it works in a roller coaster case.

Q: Here let’s just draw a free body diagram.

“A”: Yeah. (gets paper and pen) Okay so here's us, and when we are at the top of the ride, both the force of gravity and normal force are both pointed downwards towards the bottom. And the centripetal force wouldd also be towards the center … ?

(See first attached picture)

My physics professor mentioned this really common misconception when he was teaching the class about centripetal force. Many students and people who have heard of centripetal force, including my friend, thinks that it is its own separate force however this is wrong. Centripetal force is the net of all the forces acting on an entity moving in a circular path.

I was debating on rather to correct their misconception and decided to do so after like fifteen silent seconds of my friend thinking.

Aside from this misconception, I found it really interesting how my friend was approaching the question. To me it resembled a student attempting to solve a physics problem.

Q: Wait remember what Gallagher said, centripetal force is not a force on its own but rather the net force which always points towards the center if the object remains in centripetal motion.

"A": So that means if you add the vectors of all the forces they have to point towards the center?

"Q": Yeah, pretty sure.

(10 second pause)

"A": Okay this may be unrelated but I just realized something. You know how you feel mad heavy when you're at the bottom of a loop and like weightless when you're at the top?

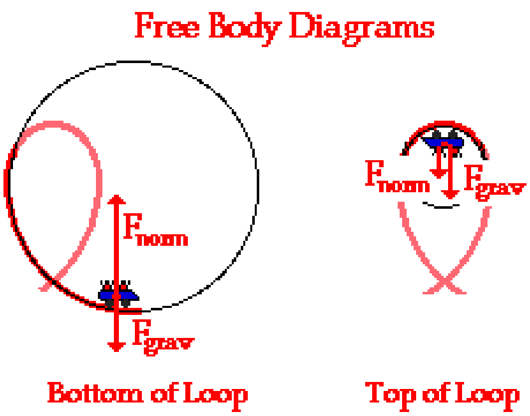
Q: Yeah what about it?

"A": So I was picturing the free body diagram of the roller coaster at the bottom and they are pretty different. Here look. So you know how the "weight" you feel is basically the normal force right?

By "they" I assume he means the free body diagram of the roller coaster at the top compared to at the bottom. I think since we were both in the same physics class, this relationship dynamic allowed for a easier connections to knowledge we both learned.

Q: Mhm.

"A": Well at the top you don't have as much normal force acting on you since the force of gravity is also pointed in the same direction as normal force but at the bottom they aren't so that means normal force must be greater for the centripetal acceleration to still be towards the center of the loop.



I think my friend was thinking exactly what's shown in the free body diagram. Since there is essentially only the normal force and the force of gravity acting on you in a roller coaster at all times and the total of these two forces have to combine to produce an inward or centripetal net force. Like my friend said, this must mean that normal force is always greater at the bottom of the loop than it is at the top because at the bottom, the normal and gravity force are in opposite directions so the normal force has to be larger than when the roller coaster is at the top to combine with the force of gravity to produce an inward force towards the center of the loop.

Q: Huh interesting, what about when the floor drops? Doesn't the free body diagram change since there's no more normal force from the floor?

"A": Yeah, I think the normal force by the ground just gets replaced with the force of friction. Wait but the force of friction has normal force in it but we just got rid of normal force. Hmm. Do you think the normal force we use for friction is the same as the normal force of the ride pushing against our back towards the center? Cause that's not in the same direction. I mean I guess that's the only way to solve it. (10 second pause) Cause look. If you have the net force in the y-direction as force of friction minus the weight and the net force in the x-direction as just the normal force then if you solve it, you would get … hold on … the co-efficient of friction times mv^2/r equals mass times gravity.

(See second attached picture)

As my friend was saying all of this, they were writing down the equations right in front of me which gave me a good insight into what they were thinking. First, they said that normal force by the ground is replaced with the force of friction, this is because the person is no longer in contact with the ground after it drops so the ground can't exert any force on the person. Second, they ended with the coefficient of friction times mv^2/r equals mass times gravity by combining the equation in the y direction with the equation in the x direction. They didn't explicitly say, but they wrote down that total force in the y-direction is 0 which is right since you are not moving up or down so the force of friction and your weight have to even out. In the x-direction there is only the normal force so that must equal mv^2/r. Finally, they substituted in normal force in the total force in the y-direction which gives you the final equation my interviewee mentioned. Later on, my friend finally realized that the velocity in this equation is the minimum it has to be so that you don't fall down the roller coaster.

We got a little off track of what my original question was but I was really satisfied of the conclusions and physics thinking that occured. I decided to cut the transcript here as the rest was not as juicy as this section.

Final Thoughts:

Coming into this interview I had two main goals. The first one was to improve upon follow questions which I had a issue with during my last interview. I tried to pay more attention to what exactly my interviewee was saying and how to properly formulate the question or even statement that I was going to follow up with. At one point, I even attempted to simply repeat what my interviewee said like Julia recommended. My second goal was to try and hopefully change the way my interviewee framed the question. I decided to not tell my interviewee that he was being interviewed until the very end and tried to get an authentic conversation in the outline of an interviewee. In addition, I also took Jared's advice of not formulating questions in the manner that gives the impression of "I know the answer but you don't so if you don't get it right you're going to look stupid".

Using these goals, I tried to see not only if my interviewees answers but also their body language and tone differed from my other interviewees. I noticed that they were definitely less scared to say what was on his mind. Especially in my first interview, there were moments where my interviewee appeared reluctant to say anything. Even when I was interviewing my sister, she felt slightly awkward on camera and also said it was because I explicitly told her that it would be public to my class. By changing the framing dynamic of this interview, I felt like I was never fishing for answers since they felt free to talk. Since my friend was so open to talk, I felt like the answers were more productive and even though we did not fully resolve my question, they came up with a lot of great ideas and conclusions on their own. I believe a big part of this was simply because they went with the flow of their thinking and did not hold anything back