Lab Quiz: Solution

I.

Jane and Harry have the following models for electricity.

*Jane’s model:* “Electricity is a lot of little particles that are pushed around the circuit by the battery, like people that are pushed around the halls of a building when a lot of people come out of a big auditorium. A light bulb is like a narrow doorway, and the brightness of the bulb is determined by the rate of flow of people through the door. Wires are the halls that lead from place to place.”

*Harry’s model:* “Electricity is like gasoline that flows out of the positive terminal of the battery into the bulb. Inside the bulb the electricity is used up in order to make the bulb light, the way a car uses up gasoline in order to run. The faster the electricity is used up, the brighter the bulb. Wires are like hoses that carry the electric flow.”

Jane and Harry are faced with the following two issues. (The bulbs are very sensitive bulbs that light if there is even a tiny amount of flow through them, and all of the bulbs are identical.)

The below are examples of good responses to the questions. Answers were graded favorably if they identified consistent, logical implications of the two models as they were stated. (It was not necessary to explain whether either model was a working model of electricity.)

A. What does Jane’s model predict regarding Issue #1? (The question is not what really happens, but what would happen if her model were in fact a working model for electricity – which it may or may not be.)

In Jane’s model, wires are the halls that lead from place to place. The wire touching the battery would be like a hall suddenly becoming accessible from a large auditorium – like an auditorium door opening. When the auditorium door opened, people would flow out the door and down the hall. They would initially crowd through the narrow doorway (light bulb), and so Jane’s model predicts that the bulb would initially light. However, the people
would soon find that the hall (wire) ended after the first door. The crowd of people would clog the hallway all the way back to the auditorium, and no more people would flow through the narrow doorway (light bulb). So the bulb does not stay lit.

B. What does Harry’s model predict regarding Issue #1?
In Harry’s model, wires are like hoses that carry gasoline (electric flow). When the wire touches the battery, it is as if a hose were attached to a tank of gasoline. The gasoline flows through the hose to the bulb, where, in Harry’s model, it is used up in order to make the bulb light. So in Harry’s model, the bulb would light and stay lit (for as long as the battery/tank of gasoline lasts).

C. What does Jane’s model predict regarding Issue #2?
The difference between the two circuits is that in one case, one wire connects both bulbs to the battery; in the other case, a separate wire connects each bulb to the battery. In Jane’s model, the first circuit is like an auditorium with just one hall leading out of it (which splits into two halls eventually, each with one narrow doorway in it). The second circuit is like an auditorium with two halls leading out of it (each with a narrow doorway). Bulb A will get half a hallway’s worth of flow, since the flow must split at the junction. Bulb B, however, will get an entire hallway’s worth of flow. Assuming all the halls accommodate a similar flow through them, Jane’s model predicts that bulb A will be dimmer than bulb B.

II.
During class discussion, a hypothetical group of students presents their method and conclusions. Here is their presentation:

“We used a balance to measure the force between two magnets. We taped the magnet to the balance and taped a yardstick to the table. Then we brought another magnet close, and recorded what the balance read. The difference between the mass of the magnet and the new reading we used as the force on the magnet. The distance between the two magnets was r. We calculated the coefficients for each of these functions, and looked at the ranges. The range for the first function is the smallest, so that is the function that fits the best. Are there any questions?”

Now it is time for the class to ask questions and discuss this group’s presentation. Assuming every student has been paying attention, thinking, and wishes to get a good participation grade, write the discussion that follows. Include at least three student’s comments/questions/critiques, one TA comment, and the responses of the presenters.
The following example has been compiled from many different student responses. It does not include every good point, but it is an example of what would be considered a good answer. Answers were graded primarily on the quality and quantity of the points brought up in the discussion.

Anne, Adrien, and Alex are the audience. Sam and Steve are presenters.

Anne: I'm confused. When you brought the magnets close together, did you have them repel or attract?

Sam: We had them repel because if we had them attract and the force was too great we could have ended up with a negative reading on the scale.

Anne: Oh, right. Good point.

Alex: I still don't get it. The magnet's mass never changes, how could you measure the force between the magnets?

Steve: Sorry, this is kind of confusing. Of course the magnet's mass never changes, but the scale is kind of tricked into thinking it does. The scale thinks the magnet is heavy just because the other magnet is pushing down on it. We could take the scale's reading for mass in kg and multiply by 9.8 N/kg to get the force the scale is reading. That force is really the weight of the magnet plus the force between the two magnets. So then we subtract the weight of the magnet to find just the force between the magnets.

Sam: We decided, since $g$ is constant, we would ignore it in our calculations. It would just be multiplied everywhere and wouldn’t change anything. Does that make sense?

Alex: Thanks. I think I get it.

Adrienne: Do you think the attraction between the magnet and the metal scale could have messed up your results?

Steve: Oh. I didn’t really think about that. Well, maybe since it’s constant throughout all our trials, it wouldn’t change our final result.

Sam: But when the magnet’s closer to the scale it would be more of a problem. I guess we should have used a plastic scale, but we didn’t have one.

Anne: Yeah. I have a problem with your conclusion. It’s true that the range of constants from function one is smaller than the other two ranges, but proportionally I’m not sure it’s all that different. Your other ranges are bigger, but so too are your other constants. You should look at a ratio of range to average.

Steve: Uh, yeah. We thought of that and decided it was a dumb idea. It’s not the proportion of the range to the average that matters, just the size of the range. If I’m aiming at a 20 cm target and hit it 1 cm off the center or I’m aiming at a 80 cm target and hit it 4 cm off the center, the ratios are the same, but clearly I did a better job by hitting it 1 cm off center.

Alex: But you’re not shooting at targets here. Of course the ranges would be bigger for $r^2$ and $r^3$, since the numbers are bigger. If you did a function with $r^{1/2}$ it would probably have a smaller range than function 1, and so you’d conclude it’s better. You have to look at the proportion.

Sam: I see what you’re saying. We’ll write that in our evaluation.
Anne: I think you should ignore the 111 constant for C. It obviously resulted from some sort of experimental error. If you get rid of that value, your range for C will be very small, which I think suggests that it's the best function.

Steve: But we took that data point. We can't just throw it out.

Alex: But maybe you made a mistake when you took it. How many trials did you do?

Steve: We only had time for one, it took us long enough to think of a method, we didn’t have enough time.

Alex: Yeah, we had a really hard time coming up with a method, too. But since you only did one trial, it could be that you messed up on that one.

Sam: Good point. I guess if we were to do this over, we would take more trials and check out that point.

TA: Any more questions? [long pause] No? Well, good discussion. Next group?