Homework #1 Possible Solutions: Laws of Physics

1. Most people got this one pretty well covered. We said in class that a law of physics is "something that always happens and you have no idea why." The most pervasive problem was using imprecise or redundant language. Just about everyone recognized the "if", but many did not see how to falsify it. To falsify a law, you need to *fulfill* the "if" and then have the result *not* happen. So if my law were "if an object is released without support underneath it from rest near the surface of the Earth, it will fall down," I could falsify that law by finding an object that did *not* fall down if I released without support underneath it from rest near the surface of the Earth (like a helium balloon).

2. Most of you identified Mechanics as the most important theory for your day-to-day life. Myself, I would probably pick Electricity and Magnetism, because it's the electromagnetic force that mediates all of our sensory perceptions, which is how we interact with the world at all. But there's nothing wrong with picking mechanics as the most important. Like I said, there's no real wrong answer for this one.

3. What I really wanted here was both an example of something from your daily life and an explanation of how you relied on the simplicity and/or predictability of nature in your example. To get full credit, you must not only have provided the examples, but you must have *explicitly* have shown how your examples answered the question.

4. There are any number of ways you could have tackled this one, so I will merely present the way I did it. There are two major *wrong* ways to do this problem: one is to try to figure out velocity or acceleration. This is not a kinematics problem. The problem explicitly stated you were not to "do math", but to look at the numbers you had and try to find patterns. Besides which, those of you who did try to use velocity and acceleration used the concepts incorrectly. We can talk more about that in class. The other wrong way to do it was to try to "fit a function" to the data, which is a process we haven't discussed at all yet, and certainly qualifies as "doing math".

Here's how I did it (which is by no means the only way, but I think it's the easiest). First of all, I noticed that the main thing that made the numbers confusing and hard to compare is the use of different units. If I want to find a *universal* "law of rocket motion" from these data, it would be better to use the same units, and even better to use no units *at all*. Since the time stamps are at

5-s intervals, I can divide that column by 5 s to get a sequence of unitless times: 1, 2, 3, and 4.

To get rid of the length units, I divided each column by the height of the rocket at 5 s. I noticed that column B then simply became 1, 4, 9, and 16, which are just the squares of the unitless time column. The other columns were close enough to the same that I attribute the differences to the "random errors" referred to in the question.

I can therefore conclude that my "law of rocketry" is that the height of a rocket at a given time, as a ratio of its height at 5 s, will be equal to the time (in units of 5 s) squared. In equation form, this looks like

$$h = h_5 \times \left(\frac{t}{5\text{ s}}\right)^2, \tag{1}$$

where t is the time in seconds, $h(t)$ is the height of the rocket at time t, and h_5 is the height at 5 s, in whatever units you like (h will then have the same units as h_5).

This formula leads to the prediction of the following heights at time $t = 25$ s: Rocket A should be around 3100 ft., Rocket B should be around 2.5 mi., and Rocket C should be around 2275 m.

Measurements that might test the validity of the law would be to get some height measurements at earlier times, in particular to see if the rocket was on the ground at $t = 0$ s. You could also keep getting height measurements at later time, and see if the rockets eventually deviate significantly from the predictions of this law. One would expect this to happen if, say, the rocket ran out of fuel.

5. To get the 5 points on this one, you had to actually come in to my office and talk to me. Just getting information from my web page or from class was not sufficient. The main purpose of this assignment was to get you to (a) find out what my office hours *are* and (b) show up at my office. Finding out something about me was just an excuse.