

Dimension Obsession

Ten-year-old (reading a magazine): “How do you figure out how fast a car can accelerate?”

Dad (sensing a teaching moment): “Newton’s law $f = ma$. f is force in Newtons, m is mass, and a is acceleration. You’ll learn that in high school.”

Ten-year old: “Then why does this car ad say ‘horsepower’?”

I’ve always been fascinated by dimensions, especially their ability to solve word problems. Suppose Mary gets paid \$5 per hour and works for three hours. Multiplying \$5/hour by three hours, the time dimension cancels just like it’s a number, and the answer is \$15. What could be simpler than that? Dimensions relate numbers to real things, like time and money. Of course, nobody knows what time really is, and people tell me that money is some kind of information. But that doesn’t affect our calculations.

Speaking of time, it’s well into summer here in Michigan, which means I can get away from the computer and do some mountain biking. Not exactly “mountain” biking, since Michigan has no real mountains, but more like hill biking. There are lots of biking trails near Ann Arbor. Along these trails, it’s peaceful and scenic, there’s no PC to stare at, and the cell phone doesn’t work.

But that doesn’t mean that I leave all technology behind. What engineer could do that? I have my mountain bike, which has a well-engineered suspension designed to handle rough trails covered with ruts, roots, and rocks. Most challenging is the hills, and the most important question of all: Will I make it up the next one?

As I approach the hill, I check my *speed*, and I realize that the higher my speed is, the better chance I’ll have to make it up the hill. *Momentum* will help when I encounter obstacles. As I slow down, I increase my *force*. I can apply

more force when I’m going slower, since I’m limited by *power*. By shifting, I multiply my force, but not my power. As I go up the hill, my *energy* changes from kinetic to potential, and I lose a lot of it because of friction.



Dennis trades his mountain bike for a Segway to get around campus.

Speed, momentum, force, energy, and power. Newton, Joule, and Watt. Who’s in charge? They’re different, in fact, very different quantities. As I climb the hill, I run the dimensions over and over again in my mind, like some kind of obsession I can’t shake. Inertia, damping, stiffness, gravity, acceleration. Each term in some governing equation has a separate role, but as I climb the hill they act together to determine what I can and cannot do. And then a revelation occurs: I suddenly see how the terms combine together in a way I never noticed before. The equations, mere ink on paper, are right

again! Newton, Joule, and Watt. Newton, Joule, and sweat.

And then there’s control: steering, leaning, pedaling, shifting, and braking. I look ahead, I note the twisting of the trail, I see its slope, and I note obstacles. I determine a trajectory and make instant decisions. Around the curves I account for centripetal and Coriolis effects, over and over again. Not enough leaning, and I won’t make the curve; too much, and I’ll skid out. Design trade-offs on the fly, with nonlinearities everywhere. But there’s nothing to compute with, no time for convergence proofs, and no error analysis. Yet the dimensions are all there, the dynamics and control laws take care of themselves, and it all comes out right. And a 10-year-old can do it without knowing Laplace transforms. Wow.

With this issue, we bid farewell to Tariq Samad, who has so gently and effectively guided *IEEE Control Systems Magazine* to its current greatness. Tariq expanded the scope, depth, and stature of this publication in so many ways. Under Tariq’s guidance, the magazine has featured articles on control system topics ranging from agriculture to computer networks to robotics. The magazine has explored the history of control systems technology, reported on current developments in the field, and even charted its future. And, most importantly, Tariq instituted its global vision, establishing an inclusive worldwide community of interacting researchers, practitioners, and students. We wish him well in his future endeavors. Thanks, Tariq!

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