Short excerpt from forthcoming book
Getting Physics: Nature's Laws as a Guide to Life
By Stephen Cohen
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Newton's Second Law (Life as a Mass on an Inclined Plane)

The motion of a mass on an inclined plane is perhaps the most classic introductory mechanics problem. Over the years, as a student, and then later as a physics teacher, I have analyzed more than my fair share of these kinds of scenarios. I must admit, as an engineer, I have yet to encounter a problem of this type in the field – I have never been asked to design a block or inclined plane, nor have I been asked to verify whether Newton's three-plus-century-old laws still apply to it.

Do I think all the time that physics students spend examining masses on inclined planes is wasted? Of course, not – the simple scenario clearly illustrates the most important law of mechanics (Newton's Second Law) and is a necessary steppingstone towards analyzing more complex situations.

There is, I believe, a secondary usefulness to examining such systems that extends beyond the practical realm. Let us take a close look at a mass as it slides up a rough inclined surface; I contend that it serves as a powerful metaphor for life. I know what you are thinking: this guy has drawn one too many free-body-diagrams. How correct you are. What can I say? Some people like romance novels. I like physics.

A free-body-diagram is a picture that indicates all the external forces that act on a given body at a given instant. The summation of these forces (accounting for their magnitudes and directions) comprises the net force acting on the body at the instant the free-body-diagram corresponds to.

In our day to day lives, Newton's Second Law is observed by all bodies at all times. It applies to inanimate objects, like a ball as it sails through the air, as well as living bodies, like my daughter as she swings at the playground. The ball's path is dictated by gravitational and aerodynamic forces, while that of the swinging girl is governed by those same forces along with the contact force from the swing and chains. At all times, the acceleration of the body in question is equal to the sum of forces acting on it divided by the mass of the body itself, or, expressed as an equation once already: $\boldsymbol{a} = \Sigma \boldsymbol{F}/m$.

We can think of the forces acting on the body as the "causes" and the ensuing acceleration as the "effect": multiple causes leading to one single net effect. It is like the pursuit of any goal in life - our progress can often be quantified, but it is usually governed by multiple factors.

A student taking a course may measure his or her success by how well the content is understood, but this is governed by the attention span of the student, the work put in by the student, the quality of the teacher, and countless other factors. One can easily measure the progress of one's career, but it is directly influenced by many factors, such as the quality of one's work and one's teamwork skills.

So, if the forces are the causes and the acceleration is the effect, then what is the mass? The mass is what links the net cause to the effect. Mass is an internal property specific to any object and is also known as translational inertia. Objects with greater mass require a greater net force to obtain the same acceleration. Mass can thus be thought of as a body's resistance to change.

Bodies with high mass require more effort to get going, although once they do, they are harder to stop than bodies having a low mass. Contrastingly, objects with low inertia respond very quickly, even to small external effects. We all resist change to a certain extent, but some more than others. Our own personal inertia may be imagined as a measure of our personal rigidity - how set we are in our ways.

We all need a certain minimum amount of inertia, without which we would not feel grounded. Imagine if all external influences took nearly instantaneous effect. We would not have time to adjust to the changes in our lives as they occur. On the other hand, if we are overly resistant to change, we will never get anywhere, and the journey of life will be a dull one.

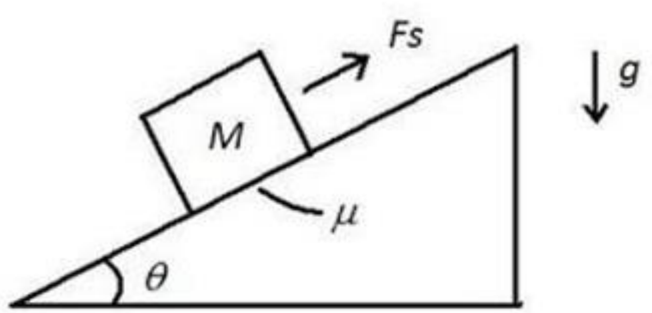

Fig 4.1: Model of a mass being pushed up an inclined plane

With these notions of force, acceleration, and mass, let us focus on one particular case: that of a body being pushed up a rough inclined plane by some external force 'F_s', as shown in Figure 4.1. In this case, the acceleration of the body up the incline is given by:

$$a = F_s/m - g(\sin\theta + \mu\cos\theta) \quad (4.1)$$

I expect all students studying introductory mechanics to take a moment right now and prove to themselves that this is indeed correct. It is, but I will sit here and wait until you are done.

Done? Cool. For the mass to accelerate up the incline, the external force F_s must be sufficient to combat the effects of gravity as well as friction, which is proportional to the coefficient of kinetic friction, μ. Steeper inclines require more external force, as do more abrasive ones. The surface gravity g is an unchanging parameter on the surface of Earth, which is related to the Earth's enormous mass and radius. Note that the F_s term is divided by m, which means that in addition to fighting gravity and friction, the external force is fighting the inertia of the block itself.

We can compare this mechanics problem to reaching virtually any goal in life. Let us equate progress up the inclined plane with progress towards finishing a difficult project at work.

To make positive strides in our project, we will need to overcome certain challenges. The incline of the plane is a measure of the difficulty of the task at hand. Some tasks are steeper than others. Perhaps the coefficient of friction can be equated to the interpersonal conflicts that occur along the way, that is, the abrasiveness of the co-workers as they attempt to interact.

The effect of the incline and friction are both proportional to the surface gravity. Well, the challenge of the task, the team in which we work – they are proportional to the work environment, which I would equate to g. A lower surface gravity is analogous to a good work environment: one that is equipped with the tools you need to accomplish your task and that has a good morale, so that positive working relationships are encouraged.

This leaves the parameters F_s and m. These are the two parameters within an employee's control, in contrast to the nature of the company (g), the other workers (μ), and the task itself (θ), which are not. F_s is the force of your*self*. Whereas the inanimate mass required an external force to move up the incline, the ability to push ourselves along is within each of us. F_s is *your* input to the project. If the quality and quantity of this force are insufficient, the project will stagnate.

As discussed previously, the mass m, represents your resistance to change, and in this case, progress. I think of it as "sometimes, people get in their own way, sabotaging themselves." Minimizing your inertia in the setting of a project means not impeding its success as it is getting going, but then maximizing it once it has picked up sufficient pace. If you can manipulate your own personal inertia on demand as a project unfolds, then you can become an agile and indispensable contributor, provided you can also output some high-quality force.

To help accelerate a project towards success, the key parameter is the self-force to inertia ratio. It must be sufficient to overcome all the challenges that stand in our way, and of which we have no control.

Note that acceleration up the incline is a step in the right direction, but it does not equal success. To succeed, we must *displace* up the incline, and to do that, we must sustain the acceleration for some time and then coast at a reasonable pace for a significant amount of time.

In life, results are not arrived at immediately. There is always some delay between cause and effect; this is the natural way of things. All matter in the Universe has at least some inertia, and people are no different. We all set our own goals; reaching them requires patience and perseverance.

As people, we will never be as consistent as the laws of physics, but we can aim to be strong and steady, like a block sliding along a surface. Furthermore, unlike the inanimate block, we can impose our will on any situation that we encounter, enabling us to follow the trajectory we wish our lives to take.

What are the challenges that are present in your life? I find that mustering up the necessary F_s to overcome them is what comes to define us as individuals. Will we minimize our m, and allow ourselves to begin to make that progress? What represents your g, μ, and θ?