A PERSONAL VIEW

The physics of an academic career

Merry L. Lindsey¹,² and Lisandra E. de Castro Brás³

¹Mississippi Center for Heart Research, Department of Physiology and Biophysics, University of Mississippi Medical Center, Jackson, Mississippi; ²Research Health Scientist, Research Service, G.V. (Sonny) Montgomery Veterans Affairs Medical Center, Jackson, Mississippi; and ³Department of Physiology, Brody School of Medicine, East Carolina University, Greenville, North Carolina

Submitted 24 July 2017; accepted in final form 5 September 2017

THE PATH FOR A SUCCESSFUL career in academia is often tortuous and at times unpredictable, and it is important to recognize the many essential skills needed to successfully navigate the system. Funding at all levels (research grants, hard-dollar support, and soft money) have become scarce and more difficult to obtain (2). While relative value units, lectures, and publications can be quantified and quality assessed as metrics of success, these alone may not be enough (9). We provide personal insight on how to attain success in an academic setting. We explain how well-known physics equations can be applied to improve your individual career path and increase your odds of goal attainment. Formulas for distance, force, momentum, and power are used to explain how to define goals and set a pace that maximizes success potential. Formulas for synergy, balance, and stress are used to highlight common obstacles encountered by both junior (untenured and early career) and established faculty and provide ways to circumvent or limit damage from setbacks. Combined, these formulas provide tips for thriving in an academic environment.

A PERSONAL VIEW

The physics of an academic career

Merry L. Lindsey¹,² and Lisandra E. de Castro Brás³

¹Mississippi Center for Heart Research, Department of Physiology and Biophysics, University of Mississippi Medical Center, Jackson, Mississippi; ²Research Health Scientist, Research Service, G.V. (Sonny) Montgomery Veterans Affairs Medical Center, Jackson, Mississippi; and ³Department of Physiology, Brody School of Medicine, East Carolina University, Greenville, North Carolina

Submitted 24 July 2017; accepted in final form 5 September 2017

How Far Do You Have to Go to Be Successful (Distance = Velocity × Time)

Since the shortest distance between two points is a straight line, clearly defining your overall career goals as early in the game as you can will help you to draw that line. The time it takes you to achieve success depends on both the distance you need to travel and the rate at which you are moving. If you want to decrease the amount of time, while keeping the same distance/goal (e.g., go up for early promotion from assistant to associate professor), you need to increase the velocity. This entails being effective and efficient to accomplish more per unit time. Periodically stopping to evaluate progress will help to ensure that you stay on a straight line; losing focus and veering off a path is very easy to do, particularly early in your career. For example, manuscript submissions seldom have deadlines, and grant submissions can always be postponed to the next cycle. Giving yourself deadlines and learning to stick to them early in your career will cement your ability to be effective. Keeping on target will also help to maximize the time available for nonwork events that are also a priority. One way to assess your progress is to compare your curriculum vitae with that of others at your stage and to others whom you consider to be successful. This both provides a yardstick to compare against and also provides examples of accomplishments you may not be documenting (e.g., judging high school science fairs as a community outreach effort, or other educational activities).

Identifying short-, mid-, and long-term goals will establish the stepping stones of your path that can be used to reach your desired destination within an appropriate time frame. By knowing the distance you want to cover and how long you want it to take, you can define the velocity at which you must work to reach that goal. Note that velocity has a direction vector, meaning you need to work hard and work smart, because working hard but in the wrong direction will not yield the results you want. In 1981, Doran and colleagues (6) developed the concept of using the Specific, Measurable, Assignable, Realistic, and Time-based (S.M.A.R.T.) method to write management goals and objectives. This technique is useful for setting short-term goals and can be useful for long-term goals, as long as you give yourself flexibility to update along the way. Setting specific rather than general goals greatly enhances the chance of these being accomplished.

To define a specific stepping-stone goal, consider what you want to accomplish, who will be involved, what you need to be
successful, and what the potential limiting factors are. Note that some of these considerations will overlap; for example, who will be involved has the possibility to be a factor that is positive or negative. Planning in advance will increase the speed by which you reach your goal and give you time to make adjustments if needed, while defining a realistic time frame to accomplish the specific goal will increase the chance of success. New research investigators often think every project can be completed within a 3-mo time frame, when actually a 2-yr window may be needed. Evaluating along the way will show if you need to increase your velocity to reach the goal in that time frame, or if you need to adjust the time to achieve your goals. As an example, Table 2 provides an outline of the steps needed to see a research project translated into a manuscript, once the experimental results have been obtained.

**Becoming a Force in Your Field (Force = Mass \(	imes\) Acceleration)**

If you are successful, you will be a strong force with potential to influence your field and peers. To become a force, you can apply Newton’s second law and consider both your mass and acceleration rate. More generally, force is an interaction that causes a change, and, when several forces act on a system, it is the net force that matters. Following Newton’s principle, if a force generates a motion, a double force will generate double the motion, whether that force is impressed at once, gradually, or successively. Therefore, independent of being a sprinter or a long-distance runner, you can increase your force. How you do it will depend on your career goals and time schedules. Along these same lines, force also equals work over distance \((F = W/d)\), and, as such, to increase your force, you either have to increase your work or decrease the distance it takes to achieve that force. The combined work equation \(W = m \times a \times d\), where \(m\) is mass and \(a\) is acceleration, demonstrates that you can build your reputation using a variety of combinations of these three components.

One way to increase your force is to increase mass or work, which can be defined as your productivity. The more quantity and higher quality of scholarly activities that you produce, the greater your mass (expertise) will become. You should be making continual forward progress, and one index of this is the need to update your curriculum vitae at least quarterly. If you have no activities to list, then it is time to evaluate the mass you are generating. Keeping a weekly worksheet that lists daily and weekly priorities and maintaining a monthly status update list will help keep you on track. Figure 2 provides an example worksheet, modified from Steven Covey’s *7 Habits of Highly Effective People* (5).

Ideally, these self-assessment activities are ones you will learn over time to perform independently; initially, using a mentor who is highly productive can help establish priorities and serve as a role model. This individual does not need to be in your circle of expertise, as priority setting is not limited by this boundary. If you are stuck on one project, take a break from it and work on another. While it is a good idea to have a high risk project that you are working on, it is also a good idea to have several bread-and-butter projects. Bread-and-butter projects are those that will yield results no matter what happens and allow you to have an index of productivity to show for your efforts. This will allow your work to stay in a positive direction and will keep your career in constant forward motion.

It may be that, during your periodic evaluation, you determine that your current velocity is not sufficient and that you need to accelerate. Any agent that increases the speed of a natural process is termed an accelerator, and, in an academic career, accelerants include having a strong network of mentors with varying expertise who, combined, help you with all aspects of your career. Having one mentor will not likely be sufficient, and having only one mentor who is also your direct supervisor will likely be rate-limiting. Think of establishing additional mentor relationships that are upwards, but also those that are sideways (peer mentors) and downwards (learning from your trainees).

### Table 1. Equations and variables, using a combination of physics and academic definitions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance</td>
<td>Amount of time and effort divided among individual priorities</td>
</tr>
<tr>
<td>Distance ((d))</td>
<td>Velocity (\times) time; achieving goals set</td>
</tr>
<tr>
<td>Force ((F))</td>
<td>Mass (\times) acceleration; work per distance; becoming an influence in your field</td>
</tr>
<tr>
<td>Mass ((m))</td>
<td>Productivity measurements</td>
</tr>
<tr>
<td>Momentum ((p))</td>
<td>Mass (\times) velocity; forward movement, resistance to stopping</td>
</tr>
<tr>
<td>Power ((P))</td>
<td>Force (\times) velocity; product of force and movement; the effort put into reaching a goal</td>
</tr>
<tr>
<td>Stress</td>
<td>(External + internal forces) divided by (support mechanisms + work efficiency)</td>
</tr>
<tr>
<td>Synergy</td>
<td>(1q + 1r) (catalyst) generates (100q + 100r); a whole that is greater than the sum of its individual parts</td>
</tr>
<tr>
<td>Velocity ((v))</td>
<td>Distance over time</td>
</tr>
<tr>
<td>Work ((W))</td>
<td>Force (\times) distance; mass (\times) acceleration (\times) distance; activities performed</td>
</tr>
</tbody>
</table>
If you are effectively managing your career, you will be highly organized, disciplined, and efficient. The starting point is to understand your priorities and ensure you carve out adequate time for your research, while spending less time with unimportant matters. Once you have achieved distance and force, the next step is to keep momentum (resistance to stopping). Generally, things will not happen just because you wish for them to occur. At the same time, it is very easy to become comfortable in a new faculty position and forget about the end-game goal. One way to keep momentum is to set specific short-term goals for yourself and your team (7). Even if you slow down for a period of time, if you are achieving your goals, then the ball is still rolling.

If visual effects help to keep you on track, graph your productivity. Several faculty keep a file with details on the number of publications, grant submissions, or students trained, which also serves a secondary purpose of providing information for curriculum vitae updates. A positive slope is always a good incentive. Remember that force is directly proportional to the rate of change of momentum with time \( F = \frac{\Delta p}{\Delta t} \). This explains why faculty who cease to have momentum also lose force (impact) in their field.

### Keeping the Ball Rolling \( (Momentum = Mass \times Velocity) \)

If you are effectively managing your career, you will be highly organized, disciplined, and efficient. The starting point is to understand your priorities and ensure you carve out adequate time for your research, while spending less time with unimportant matters. Once you have achieved distance and force, the next step is to keep momentum (resistance to stopping). Generally, things will not happen just because you wish for them to occur. At the same time, it is very easy to become comfortable in a new faculty position and forget about the end-game goal. One way to keep momentum is to set specific short-term goals for yourself and your team (7). Even if you slow down for a period of time, if you are achieving your goals, then the ball is still rolling.

If visual effects help to keep you on track, graph your productivity. Several faculty keep a file with details on the number of publications, grant submissions, or students trained, which also serves a secondary purpose of providing information for curriculum vitae updates. A positive slope is always a good incentive. Remember that force is directly proportional to the rate of change of momentum with time \( F = \frac{\Delta p}{\Delta t} \). This explains why faculty who cease to have momentum also lose force (impact) in their field.

### Power Up \( (Power = Force \times Velocity) \)

In terms of mechanical engineering, power is the product of force and velocity. Therefore, the more effort (force or velocity) you put into reaching a goal, the sooner it will be achieved. The concept of mechanical advantage states that, if there is no loss in the system, the input power will equal the output power (4). While this is never true in reality, minimizing system loss will increase your output power. Some loss is unavoidable, such as rejection of a manuscript or grant, which slows you down by having to take additional time and effort to accomplish that goal. Receiving criticism is a part of your daily routine. Journals reject article submissions, grant proposals come back with critical evaluations, and editors and reviewers advise on rewriting or adding further experiments before pub-
lication. The key is to become empowered by criticism, to use it as a driving force to increase your speed and ultimately your power. After all, one of your own roles is to provide constructive criticism to others. You are not singled out for criticism; thus be receptive to constructive criticism and use it to your benefit to become a stronger force. If your manuscript is rejected, turn the disappointment into energy and use it to improve your manuscript and submit a stronger version the next time. Whenever a grant reviewer identifies a flaw in your submission, work to ensure that flaw is not relevant in a resubmission and in future applications. The second law of thermodynamics tell us that energy and heat dissipate over time; thus use your energy while you can (3). Extracting work from the heat of rejection will lead to a better and more efficient use of your career engine. Give yourself a day to feel bad, then develop a plan and move forward. Along those same lines, there needs to be a balance between potential vs. activated energy. For example, potential energy is created by doing lots of experiments that build the story of a manuscript. Activated energy is the act of actually writing the manuscript and publishing the results. A common problem to avoid is building up too much potential energy before converting it to activated energy. Assessing your meeting abstract-to-journal article ratio is one way to evaluate this potential pitfall, with the lower the ratio being the better and a ratio >1 being a trouble indicator.

In terms of electrical engineering, power is the average amount of work done over time. In this case, work done is energy converted, and time wasted yields losses in work productivity. Minimizing activities that will not yield productivity are crucial to establishing your career. Time wasters can be defined as drag force, and these activities always move in opposite direction to career motion. In other words, your efficiency equation should always be $>2$ (efficiency = work out/energy in). Any commitment that takes away from forward momentum should be avoided. Often, events that allow us to procrastinate are conscious (or subconscious) efforts to put off doing what we know we should be doing: power through these delays and just get things done. Your mentoring committee can help you identify which commitments fall in this category. As a general rule, new commitments should not be accepted without taking a few days to consider. As your career progresses, each new commitment should also be accompanied by an assessment of whether to relinquish old commitments.

Mentor and Be Mentored (Synergism)

Advancing in your career will be easier and quicker if you have support from those above you, as well as your peers. Synergy is the creation of a whole that is greater than the combined efforts of the individual parts. While there is not actually a physics equation to define synergism, we can show it mathematically as $1q + 1r$ (catalyst) $\rightarrow 100q + 100r$. There are two examples where your career path can use synergism. The first example is in establishing collaborations that are mutually beneficial for all sides. Harnessing the strength of individual components will allow forward momentum to occur along an easier path. Collaborations can increase your capabilities without having to acquire that expertise on your own and can occur at many different levels of cooperation, from providing advice to actually working as a co-investigator or co-principal investigator on a project. One consideration for creating collaborations is to make sure that both sides benefit equally: just because you can help someone does not mean that it is in your best interest to do so. It is not selfish to keep your actions focused on your own goal achievement. There are many ways to be synergetic, particularly with your peers. One way is to use each other for individual problem-solving discussion. Another example is the use of the appreciative inquiry process as a means to analyze issues and make decisions (1). This approach uses a model that engages stakeholders in self-determined change activities.

Another area where you can take advantage of synergism is within your own efforts (self-synergism). This recycling, whether it is using common protocols across projects, reanalyzing samples used for another purpose, or developing broad-stroke concepts that span topic areas, is a highly effective way to be productive. All of these activities reduce the activation energy to start a project, making it easier to complete new projects that range from incremental to large jumps from the previous project. Take time to consider how each individual activity fits into the larger picture, and whether recycling across activities is possible. This does not mean plagiarism or duplicating experiments, and there are rules on how to report previously published results in new publications; rather, this means taking advantage of having a big-picture goal in which to place component parts. This also means maximizing efforts whenever possible. For example, the literature analysis performed to prepare the background and significance section for a grant can easily be recycled into a comprehensive review article on that topic. This would give you a publication and also help to document your expertise in this area.

Balance

Another concept that is not captured by a physics equation but is important to mention here is balance (equilibrium), which can be described by the equation: $4x + 1y + 1z = 2x + 2y + 2z$, where $x$, $y$, and $z$ are individual priorities (e.g., research, teaching, and family). There are two important ideas to consider in balancing your life. The first is that, given the law of conservation of energy, both sides of the equation must balance: you cannot add time to your schedule. Therefore, if you say yes to everything or even to any item that is not important, you dilute (or worse, cannot say yes to) items that matter most. Identifying which items are priorities will help to ensure adequate preference is given. This also makes it easy to say no to activities that do not help you to attain your goals. Along these lines, there are activities (e.g., manuscript reviews) that are critical for you to commit to early on in your career, because reviewing manuscripts helps you be a better researcher yourself, provides a service back to the research community, and helps you to make a name for yourself with editors. Later, as your role shifts to serving as associate editor or editor for a journal, you can shift the reviewing priority to the new generation whom you have trained to be effective reviewers. Knowing when to let go of a priority is also key to time management.

The other concept is that the amount of time and energy devoted to $x$, $y$, and $z$ are in flux. This means that you can be flexible over time and devote varying amounts of time to each activity, as required for the present set of goals. While your long-term goals should stay relatively constant, the immediate...
goals that you set as an assistant professor will vary from the immediate goals you set as an associate or full professor. Balancing between professional and personal goals will also help you to organize and prioritize activities and ensure both goal sets are met. While balance means that you are not always at work or not always at play, it can mean that some weeks you are always at work (e.g., the weeks before a grant is due), and some weeks family is the focus. Being able to focus in on one task is an important component of goal completion.

**Stress (Stress = Force/Area)**

Effectively managing research, teaching, and service activities, in addition to a personal life, will take a concerted effort to achieve your desired level of balance. There will be periods of stress along the way. Stress increases when external or internal forces increase. To achieve balance between a successful career and a satisfying personal life, you need to spread out your area of support. Having a network will help you here, both for practical advice as well as serving as a sounding board. This goes back to having a mentoring community rather than one individual. This also means including your family or friends in your plans. Strong and colleagues (8) lead a study on challenges physician-researchers encounter on work-life balance. In-depth interviews revealed how gender and spousal/family dynamics make work-life balance more challenging for women and also identified mentoring as having a big impact on promoting the satisfaction and success of researchers (8). Having a support system at home is highly recommended. Along these lines, while junior faculty always want to go as fast as possible, sometimes going slow can yield more forward progress than going fast, particularly if going fast means you have to reverse to correct mistakes or if it means going off the right path and losing sight of your goals. The burnout equation defined for rocket performance includes principal performance, efficiency of propulsion, structural design, and fuel consumption as critical components. Developing strategies to alleviate stress along the way will minimize your burnout potential.

In summary, work hard and work smart, network, take the time to establish a solid reputation, synergize as much as possible, maintain professional and work-life balance, and do what you can to minimize stress. Once you have achieved success, the next step is to avoid inertia, which is the resistance to change. Defining for yourself what success means and following the steps above to achieve your individual goals will minimize this likelihood. We hope that applying these concepts to your career will provide a plan that works for you.

**GRANTS**

We acknowledge support from American Heart Association Grant 14SDG18860050; from the National Heart, Lung, and Blood Institute (HL) and the National Institute of General Medical Sciences (GM) of the National Institutes of Health under Award nos. HL-075360, HL-129823, HL-051971, GM-104357, GM-114833, and GM-115428; and from the Biomedical Laboratory Research and Development Service of the Veterans Affairs Office of Research and Development under Award no. 5101BX000505.

**DISCLAIMERS**

The content is solely the responsibility of the authors and does not necessarily represent the official views of the American Heart Association, the National Institutes of Health, or the Veterans Administration.

**DISCLOSURES**

No conflicts of interest, financial or otherwise, are declared by the authors.

**AUTHOR CONTRIBUTIONS**

M.L.L. conceived and designed research; M.L.L. and L.E.d.C.B. prepared figures; M.L.L. and L.E.d.C.B. drafted manuscript; M.L.L. and L.E.d.C.B. edited and revised manuscript; M.L.L. and L.E.d.C.B. approved final version of manuscript.

**REFERENCES**