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Some Basic Truths
The Obligatory Preamble

What the Book Does and Does Not Do:

- **Provides the reader** with a basic overview of race car kinematics, race car dynamic performance characteristics and a myriad of set up possibilities. The book walks the reader through a large number of kinematic (motion related) and dynamic performance examples. The accompanying software packages are used to help clarify the components discussed in the book and to allow the reader to work beyond the confines of the book. However, in order for this book to work, the individual must put the theory into practice - in the shop, on the computer and on the track. If you can't get your head around a particular bit of information, try building some models. A working model is often invaluable but never lose sight of the fact that nothing replaces hands-on practical experience.

- **Provides the reader** with an overview of how to go about setting up a race car. The first book together with its four companion books have two primary themes: (a) an understanding of the basics of race car dynamics and (b) an understanding of how to use that theory - so much to learn and so little time in which to do it. The race engineer that can glean the greatest amounts of useful information in the shortest amount of time and with the least amount of money will play a major role in his/her team's success.

- **This is not a generic how to book** - It will not tell you that if your car is loose in the middle of the corner, "reduce the front spring rate by 50 lb., and the thing will be a rocket ship". Racing is not that simple. If it was, we would all be fast at every track under all circumstances with any driver and we would all quit racing. We would quit because it would be boring. Racers race because of the challenge. Despite what we all say, no-one would want to win 100 percent of the time. What fun is that? The joy in winning comes from the endless struggle to get there.

- **There is no demon tweak, no killer set up, no flavour of the day** – Ninety-five percent of the "fast set up" is simple logic, endless, meticulous care and an extensive understanding of race car dynamics. At least two thirds of any race car field, even at the highest ranks, are running cars that are not immaculately prepared, fully sorted and/or fully understood. Running at the front of that last third in a highly professional series is not the result of one, or even twenty special engineering, preparation and/or set up advantages. Running at the front is the result of thousands, if not tens of thousands minute engineering, preparation and set up advantages. The so-called "unfair advantage" is nothing more than fanatical devotion to careful engineering, preparation, set up procedures and **lots** of money.

- **Spelling it all out** - Race car performance can often be nothing more than a hit or miss proposition if the team does not understand the basics of how a chassis works under both static and dynamic conditions. Throughout the book, I repeatedly refer to the saying, "*It's just not that simple,"* for one simple reason and that is because it is "*just not that simple"*. If you are looking for a book that spells it all out for you (gives you all the set up changes in black and white), then this book is not for you. I can also tell you uncategorically that if that is what you want, you are never going to make it to the top of your profession. Teams don't consistently run at the top because they have a **little** set up book that tells them in two sentences
or less what to do. That sort of thing only exists in the dreams of the also ran's – period! The if /then scenarios top teams use are held in large data bases and even that is useless if the person using it doesn't

understand the principles of vehicle dynamics. What this series of books attempts to do is provide the reader with a race car dynamics knowledge base through looking at race car kinematic and dynamics in both **practical** and **theoretical** terms. It is from this knowledge base that the race engineer is able to determine what changes need to be made to help both chassis and driver performance.

- The bottom line is that even if you completely understand all of the concepts presented in this and every other vehicle dynamics book ever written, that still will not make you the race engineer guru. You also need to amass a considerable amount of useable, practical empirical knowledge and the only way to accomplish that is by actually doing it. Don't ever let an experience slip by without gaining useful and useable knowledge. Understanding why something didn't work is at least as important as understanding why something did work. Additionally, if you don't have a way of retaining and reusing that knowledge, it soon will not matter whether you understood it or not.

- If you don't find a way to know what you have learned and then document those findings, all the experience in the world is for naught. The preponderance of race teams go through test after test, race after race, year after year without knowing what they have learned let alone carefully documenting it. It sounds simple but it is not. Developing ways to gather, store, analyze and successfully use test and race data is a mind boggling undertaking i.e. *It's not that simple*. A race engineer must not only understand race car dynamics, he/she must also be able to use that knowledge and you know what – *it's not that simple*. Intuitive is not a word top race teams use. A competitive advantage in the top one third of most professional series is measured in very, very small increments.

> *"Lucky are those who dream dreams and are willing to pay the price to make them come true*.
> Author Unknown

- **This is a basic book, not necessarily an easy book** - Even the most basic concepts involved in race car dynamics can be pretty daunting for the racer who is just beginning his or her journey on the road to understanding how that darn race car works. If you are new to all of this but still able to comprehend the material in this first book, and, in turn, put it to practical use after only one read through, then you are many times smarter than the author together with ninety-nine percent of the rest of the racing world. Like any subject worth pursuing, be it mathematics, mechanical engineering, music or whatever, you must put in the time and effort. This book will **not** put in the time and effort for you - sorry.

- **Personal Note**: If you want to know whether you truly know a concept, try clearly writing it down in a manner people will be able to understand. Now that is one scary task! I have tried my best to explain things clearly and correctly but I have absolutely no doubt that there are places where I have come up short on both counts because in some cases I haven't been able to dedicate sufficient time, and, in others, because I just plain got it wrong – after all, I am just a simple farm boy. To this end, if you have something **constructive** to add, please email me at warren@rowleyrace.com I am not **at all** interested in bench racer talk. If you haven't been there and done that, then don't waste your time and mine. On the other hand, if you find a theoretical mistake in the book or if you have something theoretically constructive to add, please feel free to email me. As I am away far more than I am home, I will not commit to emailing you back but I will at least read and think about your comments. Race car dynamics is still a developing science and there is still much to learn. I freely admit I don't have all the answers and I don't **ever** want to work with people who think they do.

DO NOT BELIEVE ANYTHING YOU READ, HEAR, SEE OR THINK

WITHOUT TESTING IT AT LEAST THREE TIMES IN AT LEAST TWO DIFFERENT WAYS.

THAT INCLUDES THIS BOOK!

THEN, ONLY BELIEVE IT WITH A CERTAIN AMOUNT OF SCEPTICISM.

Some Basic Truths:

- Testing three times in at least two different ways is the bare minimum for everything a race engineer undertakes. It is generally a good idea to test new concepts and ideas through on track data, mathematical formulas, computer simulation and shop/lab empirical data. If you test using each of these methods three times and in two different ways and the data from each of the methods is within 5%, you can be quite confident your data is correct. **Who Are You Kidding**? Race engineering is **very much** about making the best possible use of the time that is available. Race engineers need to live in the real world of time and cost restraints just like every other member of the team. Race teams never have enough time and money to test everything so probability and statistical methods need to be developed to help the team learn **more** in **less** time. That is one of the race engineer's major jobs ("He who pontificates too long gets punted"). Many new engineers have a tendency to become fixated on just one small thing and lose sight of the big pictures.

- Keeping accurate, well-organized retrievable records and notes is a major key to success - - easy to say, hard to do.

- The line between too much theoretical information and not enough is a fine one. If ever there was an understatement, this is it. To quote the mathematician, JanVan de Snepscheut (1953 -1994), **"In theory, there is no difference between theory and practice. But, in practice there is**".

- **Basic Traits of a Race Engineer:**
  - a modicum of intelligence
  - a modicum of math and engineering skills
  - the ability to collect, organize, document and analyze pertinent information
  - the ability to communicate
  - a modicum of creativity
  - a modicum of logic
  - All of the above pale in importance compared to an unrelenting drive to know - to be totally obsessed with the need to find the questions, ask the questions and answer the questions - to succeed beyond all others. Plus, first and foremost, a successful engineer must have a highly developed set of leadership skills.

Personal Note: It is my strong belief that beyond the academics, the ideal race engineer must have a thorough background knowledge in every part of the race car including well-developed fabrication skills, maintenance skills and set up skills. In fact, all engineers should be able, **or at some point,** been able to make and maintain what they design. It is my most humble opinion that theory alone is as useless in racing as it is in most other complex endeavours - there are way too many variables in racing for theory alone. Please don't get me wrong; I very strongly believe the theoretical world has a major role to play in any successful race team. However, theory alone will never win the day.

The race engineer must also have had time behind the wheel of a race car. If the engineer has not felt what the driver feels, he/she will never really understand race level vehicle dynamics. It is impossible to describe or understand the complexities of race car dynamics without experiencing them. I have never met anyone who was not totally blown away with the first time experience of riding with a top level driver running at 99% on a road course.

From Formula SAE up to and including Formula 1

- Decisions and changes driven by one's ego have no place in racing.

- Decisions and changes guided only by intuition have no place in racing.

- Decisions and changes based only on, "Well, that's what worked before," have no place in racing.

- Decisions based on, "Gee, that will be a lot of work", have no place in racing.

- Decisions and changes based on what you think another team is running has no place on race day.

No one book, person or team has all the answers.

- Gather information from every source you can find.

- Don't ever waste an experience. There is always something new to learn even though sometimes you have to go looking for it.

Just a Few of the Must Have "Five Star" Books and Magazines:

- "Race Car Vehicle Dynamics" *by* William F. Milliken and Douglas L. Milliken

- *"New Directions* in Race Car Aerodynamics" *by* Joseph Katz

- "Formula 1 Technology" and "Ferrari Formula 1" *by* Peter Wright

- "The Racing & High-Performance Tire" *by* Paul Haney

- All of the Carroll Smith "To Win" Books, particularly "Drive to Win"

- Inside The Ohlins TT Manual – (Ohlins Damper Manual)

- Pi Aerodynamic Application Notes (from the Pi V6 manual) – in fact, you should read all of Pi's technical material. It is extremely well-written and much of it can be accessed via their web site.

- "The International Journal – RACECAR engineering" *(Magazine)*

- "Technology, Business and Mechanics" – RACE TECH *(Magazine)*

- Claude Rouelle's seminars. I have not personally attended one of Claude's seminars but I have heard nothing but good things about them.

Important Note: By the time you read this book, I will no doubt have changed my mind regarding some of the theories presented within these pages. After all, if you stop looking and trying to understand how a race car works, you will soon be left behind in this high tech game. An unfortunate side effect of gaining knowledge is that it also expands your sphere of ignorance. The one thing I can guarantee is that anyone who thinks they know it all – DOESN'T.

Be Aware of Bench Racers, Old Wives' Tales and Good Old Folk

And More:

- Vehicle dynamics is an extremely complex field of study. Book One only covers the first few steps of a very long and complex journey. In fact, the combined five book series still only covers the first few steps.

- Book One only covers the most common types of suspension systems. Book Three covers a much wider range of suspensions.

Important Disclaimer

To the teams for whom I have worked and/or with whom I am currently working:
Great care has been taken not to disclose any confidential/proprietary information, particularly suspension co-ordinates, set ups, aerodynamic settings, pictures of the shops, cars and/or team procedures.

I very much like what I do for a living and I am not about to do anything to compromise any present and/or future employment. In my consulting work, I have had the privilege of working with a number of great teams and I have never, nor will I ever, risk future opportunities by breaching any confidences. Racing is, by nature, a confidential/proprietary business. I do and will continue to respect those boundaries.